MONOPOLAR VERSUS BIPOLAR TRANS-URETHRAL RESECTION OF BLADDER TUMOURS (TURBT):

A SINGLE CENTRE PARALLEL ARM RANDOMIZED CONTROLLED TRIAL

"MONOPOLAR VERSUS BIPOLAR TRANS-URETHRAL RESECTION OF BLADDER TUMOURS (TURBT): A SINGLE CENTRE, PARALLEL ARM RANDOMIZED CONTROLLED TRIAL"

A dissertation submitted to The Dr. M.G.R. Medical University, Tamilnadu, in partial fulfillment of the requirements for M.Ch. Branch-IV (Genitourinary surgery) examination to be held in August 2013.

Department of Urology

Christian Medical College and Hospital

Vellore, Tamil Nadu

Certificate

This is to certify that the work incorporated in this dissertation entitled "**MONOPOLAR VERSUS BIPOLAR TRANS-URETHRAL RESECTION OF BLADDER TUMOURS (TURBT): A SINGLE CENTRE, PARALLEL ARM RANDOMIZED CONTROLLED TRIAL**" is a bonafide work done by Dr. Vivek Venkatramani in partial fulfillment of the rules and regulations of MCh Branch IV (Genitourinary Surgery) examination of the Tamil Nadu Dr. MGR Medical University, Chennai to be held in August 2013.

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Monopolar versus bipolar trans-urethral resection of bladder tumour (TURBT): A single centre, parallel arm, randomized controlled trial.

Introduction:

Cancer of the urinary bladder is among the commonest malignancies in the world and has a high mortality rate. The initial management in all cases consists of a complete trans-urethral resection of the bladder tumour (TURBT), with a histopathological analysis on which further treatment decisions are based.

Trans-urethral resection was introduced early in the 20th century and has remained the mainstay of surgical management since then. Technical modifications have enabled the safer and more efficient performance of the procedure, however complications remain.

Bipolar resection allows electric current to return to the machine via an electrode in the resectoscope itself. Hence no current passes through the patient, and no separate earthing electrode is required. It has been established in the last decade as an excellent alternative for trans-urethral resection of the prostate (TURP). It offers the option of resection in normal saline (a physiological solution), thereby reducing fluid and electrolyte abnormalities, and allowing prolongation of the procedure with a more complete resection. The hemostatic properties of this system have been claimed to be superior to the traditional monopolar cautery. In TURBT, the bipolar system also offers the possibility of reduction of obturator jerks, which can otherwise lead to bladder perforation. Numerous randomized controlled trials (RCT's) exist for TURP and have proven the equivalence and safety of the bipolar system. While the above

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Contents:

Introduction

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With this in mind we decided to conduct a randomized control trial comparing the bipolar system with the traditional monopolar cautery for TURBT.

Aims and Objectives

The role of bipolar cautery in the performance of TURP has become well-defined; however, its place in TURBT remains unclear. This is due to the paucity of good randomized studies in this area.

The aim of our study was to perform a randomized controlled trial to compare the safety and efficacy of bipolar resection of bladder tumours with the current standard of monopolar resection.

The safety of the procedure was assessed by comparing the mean blood loss, need for blood transfusion, drop in hematocrit (PCV), incidence of TUR syndrome, obturator jerk and bladder perforation between both arms.

The ***primary end-point*** used to assess the safety of resection was the incidence of obturator jerk among both groups, and this was the parameter used to calculate the required sample size for the study. The others were considered secondary endpoints.

The effectiveness of the resection was addressed using standard parameters that are used to assess the '***quality'*** of a TURBT. These are mainly pathological and include presence of gross residual tumour, presence of deep muscle in the biopsy sample and degree of cautery artifact in the specimen.

Review of Literature

Epidemiology of bladder cancer:

Cancer of the urinary bladder is the ninth most common cancer worldwide accounting for 7% of all malignancies, with an estimated 68,810 cases diagnosed in the United States in 2007. (1) Worldwide, the incidence appears to be increasing, especially in developing countries like India, due to an increase in the prevalence of smoking. (2) Smoking cessation programs appear to have reduced, but not completely negated this rising incidence. (1,2)

Muscle invasive bladder cancer has a high mortality, and accounts for almost 145,000 deaths annually. (2)

Rationale and technique of TURBT:

Physicians tend to classify bladder cancer as superficial/ non-muscle invasive, and muscle invasive. This has tremendous prognostic, as well management, significance. This classification requires histo-pathological evaluation of the primary tumour, with an assessment of the stage and grade. This is performed by trans-urethral resection of the bladder tumour (TURBT), which is the standard initial treatment of all bladder tumours. (3) TURBT was first introduced by Beer in 1910, (4) and has stood the test of over a century.

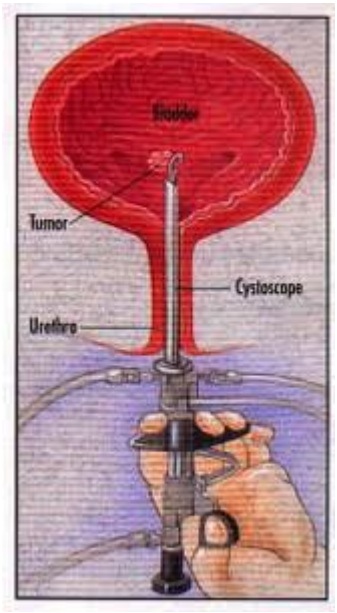


Fig. 1: Trans-urethral resection of bladder tumours (diagrammatic representation)

TURBT is the most common uro-oncological procedure performed by practicing urologists, with over 39,000 of these procedures performed annually in the United Kingdom. (5)

The traditional aims of TURBT are: (5,6)

1) Identification and documentation of all tumours in the bladder

2) Complete resection of these tumours

3) Accurate staging of each tumour

4) Identification of areas of carcinoma-in-situ (CIS) within the bladder

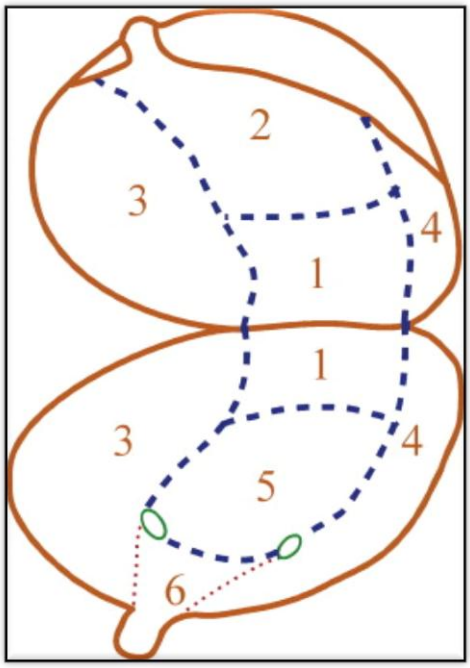


Fig. 2: A 'Bladder Map' used to document TURBT findings

Complete visualization of the bladder is best achieved using a 70-degree cystoscope which allows optimal visualization of the anterior wall. Subsequently, the TURBT is performed using a resectoscope loop passed through a 30-degree cystoscope. Bladder distention is controlled using the continuous irrigation-suction system to prevent over-distention of the bladder and possible perforation. The introduction of the video camera system allows magnification and better documentation of findings. It also

facilitates teaching trainees, and allows the performance of the procedure with reduced exposure to body fluids.

Resection of the tumour is carried out using a piece-meal technique, utilizing the stalk of the tumour to maintain counter-traction. Cutting current is generally used, however small; friable tumours may be broken off using the loop itself. The base of the tumour is then coagulated, thereby achieving hemostasis. Once the whole tumour has been resected, an additional sample from the muscle in the base is obtained. This allows the determination of the depth of invasion of the tumour. (6) The findings of the procedure are documented using a diagrammatic 'bladder map' which allows easy follow-up of the patient.(7) Tumours in the region of the ureteric orifice can be freely resected using the cutting current without the risk of cicatrisation.

Fig. 3: Cystoscopic image after completed resection

This piece-meal technique of resection has remained the standard for decades; however, critics suggest that this is responsible for the high recurrence rate of bladder tumours. (7) This recurrence was postulated, by Albarran and Imbert, to be due to

implantation of floating cancer cells. Genetic studies also suggest that recurrences are monoclonal, lending credence to the theory of implantation. The high rates of recurrence at the bladder dome also support this theory, (7) as does the significant reduction in recurrence with the use of single dose intravesical chemotherapy following TURBT. (6,7) To tackle this, researchers have described methods to perform en-bloc resection, the so-called 'sand-wedge' approach. (7) Saito (8) and Thomas (7) have described the use of a knife electrode to perform en-bloc resection of the tumour with a rim of normal tissue. Saito propagates the use of Holmium laser for en-bloc resection of tumours at the bladder neck. Ukai et al have used a modified loop, which is bent to form a 'J' to perform en-bloc resection. (9) These techniques have not found universal acceptance beyond a few restricted centres and are currently not considered standard of care.

Types of cautery used in TURBT:

High frequency current has been used in the performance of trans-urethral resection for many years.(10) A high-frequency voltage is generated and it drives current through the patient via the cutting loop. The generator produces current at a frequency of > 100,000Hz which prevents neuro-muscular stimulation and is therefore safe to use. (11) The current returns via the grounding electrode. The patient is therefore a part of the circuit, and the current flowing within him/her heats the tissue. The heat produced depends on the current density and is significant only very near the loop. The cutting effect is proportional to the current density and not dependent on the frequency of the current. (10) High frequency currents and voltages are required for cutting and coagulation; however the heat production required is less during coagulation. In order to produce a coagulation effect the applied power is reduced by pulsing the generator output. (10)

In a ***monopolar circuit***, a return electrode on the skin completes the circuit. This is generally placed on the thigh or buttocks. (10,11) A high voltage is required to drive the current back to the return electrode, and increases proportionate to the distance within the patient that the current needs to travel. (11) The skin pad has a large surface area of contact so as to reduce the energy density at the point of exit and prevent thermal burns. Monopolar circuitry mandates the use of non-conducting hypo-osmolar solutions like distilled water or glycine, as they do not dissipate current from around the cutting loop. (6) The use of these solutions raises the potential for fluid and electrolyte abnormalities and puts an upper limit on the duration of the procedure. (11)

A ***pseudo-bipolar system***, termed transurethral resection in saline (TURis), was designed in the early part of this millennium. The return electrode is incorporated in the outer sheath of the resectoscope and current returns through the urethra or penis. (12) A higher stricture rate was reported following this and its use has fallen out of favour. (11,13)

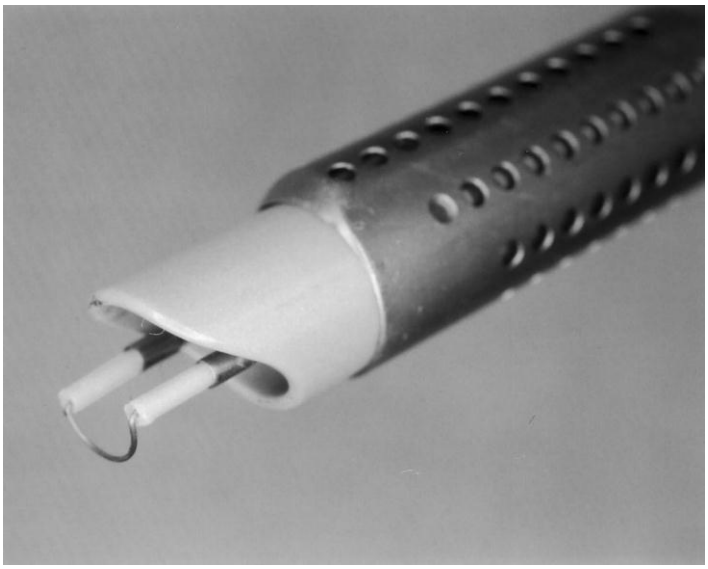


Fig. 4: TURis system with return electrode along the outer sheath

A ***bipolar circuit*** is defined as one in which both the active and return electrodes are attached to a single support system. (11) In TUR systems, these electrodes are incorporated within the resectoscope loop itself. This limits the transmission of current through the body and allows the use of lower voltage as the resistance to flow of current is reduced. The most commonly used system is the plasma-kinetic system. Energy transmitted to the cutting loop causes evaporation of the surrounding liquid thereby creating a resistance to the flow of current. When a voltage is applied, sodium ions within this layer of gas are excited to a higher energy plasma state. Once the plasma is generated, only low voltages are required to cut tissue. The loop is made of

a platinum-iridium alloy which is able to resist the effects of plasma. A super-pulse generator is required, in order to deliver enough current to consistently generate plasma, irrespective of flow conditions. (11) To coagulate tissue, voltage is kept low so as to prevent plasma generation. As a result, the resistance at the liquid-gas interface remains high and heat is generated. The heat gets dissipated within vessel walls, forming a coagulum of blood and tissue that stops bleeding. It occurs simultaneously with cutting and prevents charring of tissue. (5,11)

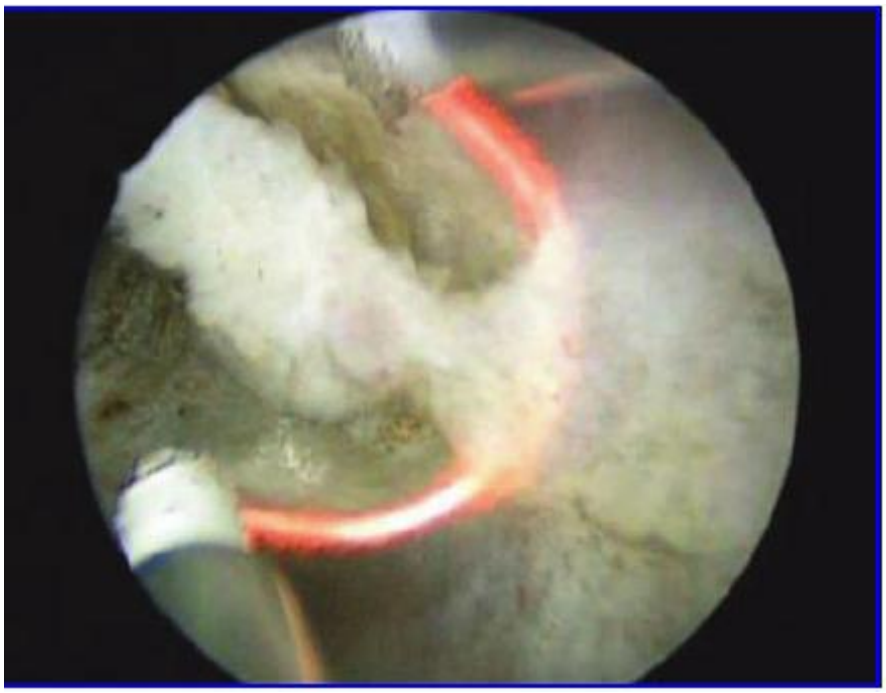


Fig. 5: Plasma generation used for cutting during bipolar resection

The major advantage of the bipolar system is the ability to use physiological irrigants like normal saline during resection. This minimizes electrolyte abnormalities and enables the duration of the surgery to be prolonged, if required. (5,7,14)

Complications of TURBT:

Although TURBT remains a challenging technique to master, it is generally a safe procedure. Complications are rare; however they can be a source of significant morbidity. Significant complications include hemorrhage, electrolyte imbalances post operatively (secondary to the use of hypotonic solutions), bladder perforations (0.9-5%), often under-estimated and with the potential for tumour implantation) and a risk of stimulation of the obturator nerve during resection of lateral wall tumours. (14)

(1) Hemorrhage: Uncontrolled hematuria requiring transfusion and/or re-coagulation of bleeders is rare, occurring in <5% of cases. (6) It predominantly occurs during the resection of large tumours, and arises from the large raw surface, or bleeders in the tumour base. In an analysis of TURBT complications in 2821 cases, Collado et al reported a transfusion rate of 3.4% with significant bleeding in 2.8%. (15) The majority of significant bleeding requiring re-coagulation was significantly associated with the size (>3cm) and number of tumours resected. (15)

(2) Urinary tract infection (UTI): The incidence of UTI following TURBT is quite variable, ranging from 2-39% in various series. (14) Conflicting schools of thought exist as to the source of the organisms, with some suggesting that infected tumour tissue is responsible, while others suggest that the endoscopic manipulation is the cause. (14)

(3) Resection of the ureteric orifices: Bladder tumours can occur near the ureteric orifice necessitating resection in this area. Cutting current is well suited for this and generally results in healing without scarring. (6) Vesico-ureteric reflux at the resected orifice with seeding of the upper tract with tumour cells is a potential complication, and has been reported in the literature. (16) Scarring of the orifice with resultant

obstruction and hydroureteronephrosis is also possible, therefore surveillance of the affected renal unit is necessary following resection of the orifice. (14)

(4) Bladder perforation: This is probably the most important complication described following TURBT. It results from inadvertent deep resection through the bladder wall or complete resection of a deep, invasive tumour. Other possible causes include perforation by the resectoscope itself, or over-distention of the bladder. (14) Rarely, bladder 'explosion' secondary to gases and air in the bladder, by a spark from the resectocope can cause perforation. (14) This dramatic event occurs secondary to the production of hydrogen during the resection of body tissue. In combination with atmospheric oxygen (introduced during irrigation or washing for chips) it becomes combustible with the potential for bladder 'explosion. (17)

Obturator nerve stimulation, during the resection of lateral wall tumours can cause sudden contraction of the adductor muscles of the thigh and result in bladder perforation. (15) This is an important contributory factor and is discussed in detail subsequently.

The incidence of bladder perforation is classically quoted to be <5%, however a majority of patients will show contrast extravasation if subject to cystography following TURBT. (6) Collado et al reported a perforation rate of 1.3% in their series. (15) Perforation is recognized intra-operatively by the visualization of perivesical fat, a dark space between muscle fibres or by seeing bowel during the resection. (14) Post-operatively, progressive abdominal distention is suspicious and ultimately uremia and peritonitis can ensue. (14)

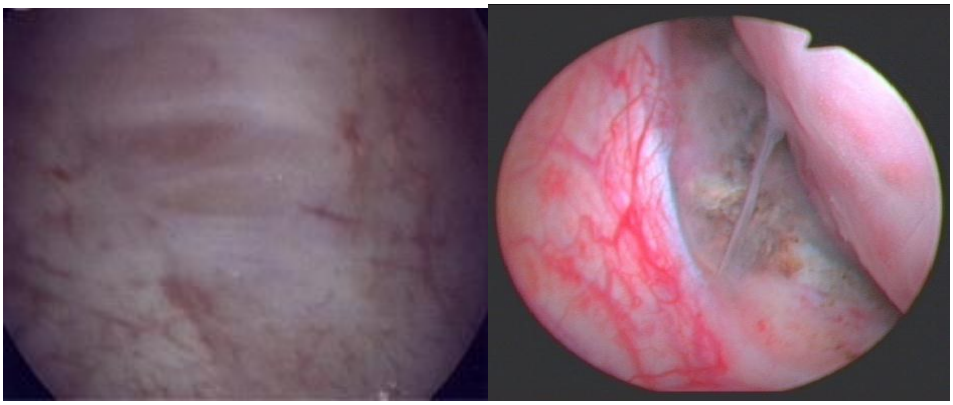


Fig. 6: Cystoscopic appearance of bladder perforation

Bladder perforations are predominantly extra-peritoneal (>80%), and these are associated with resection in the posterior and lateral walls of the bladder. (18) Extra-peritoneal perforations can be conservatively managed with prolonged catheter drainage with <10% of cases requiring surgical repair. (6,14,15) Intra-peritoneal perforations are less common, and occur mainly during resection at the dome. Small intra-peritoneal perforations may be managed conservatively with abdominal and bladder drainage. (15) For larger perforations, or those with super-added infection, surgical repair (either open or laparoscopic) is indicated. (6,14,15,18)

One important theoretical complication of bladder perforation is the possibility of implantation of tumour cells into the peritoneal cavity. Isolated reports suggest that this can occur, however the incidence is extremely low. Follow-up of these patients for the development of any intra-abdominal metastases is prudent; however the majority will remain free of any such event. (14,15)

(5) Irrigant absorption and the development of TUR syndrome: Conducting fluids like normal saline dissipate monopolar current, and hence hypotonic fluids like glycine or distilled water are commonly used for TURBT. (6) Absorption of these

hypotonic fluids into the circulation can cause fluid and electrolyte abnormalities, hypertension as well as hemolysis. (14,19) Dilutional hyponatremia can cause osmotic flux of water out of the intravascular compartment, with resultant hypovolemia, hypotension and metabolic acidosis. (19) In a TURBT, irrigant absorption occurs secondary to bladder perforation and subsequent equilibration of fluid and electrolytes across the semi-permeable peritoneal membrane. This requires time, and TURBT syndrome generally occurs two to ten hours following surgery. The net deficit of sodium is large due to dialysis by the peritoneum, and the magnitude of the disorder is often more serious than TURP syndrome, which occurs rapidly following direct intravascular absorption of fluid through the prostatic sinuses. (19) The incidence of this disorder following TURBT is extremely rare, and is practically eliminated by the use of bipolar current which allows resection using normal saline.(7,14,20)

(6) Obturator nerve stimulation and adductor muscle contraction (obturator jerk): High frequency current, as used in the monopolar TURBT, passes through the patient on its way back through the inactive electrode, and during this journey can stimulate the obturator nerve which lies in close proximity to the lateral bladder wall. (20) This can result in sudden inadvertent contraction of the adductor muscles. A violent 'kick' can cause the resectoscope to perforate through the bladder wall. (14,20) Subsequent difficulty with resection predisposes to incomplete removal of the tumour. (20)

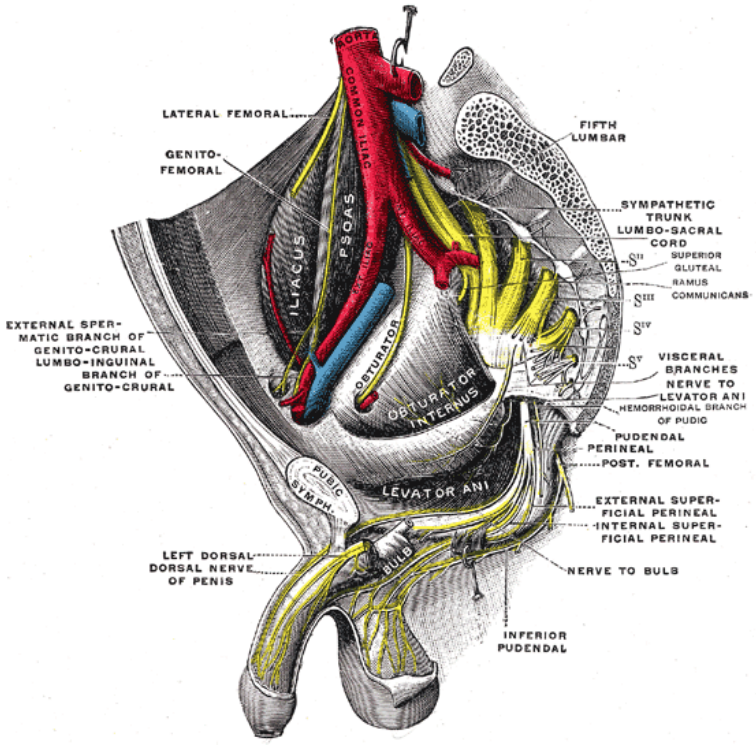


Fig. 7: Intimate relationship of the obturator nerve with the lateral bladder wall

The obturator jerk is actually not considered a complication, (15) but is a frequent occurrence during the resection of lateral wall tumours. (21) The exact incidence varies widely in literature. Tumour location, and the use of techniques known to reduce obturator reflex (discussed subsequently), are sometimes not detailed in studies, making it difficult to judge the true incidence.

Kihl reported a rate of 10.6% in 160 TURBT's performed using the monopolar system. (22) McKiernan et al reported a rate of 11% for TURBT with no instance of bladder perforation in these cases. (23) Khorrami et al reported an incidence of 34% in those who did not undergo obturator block and had TURBT under spinal anesthesia. (24) In a prior study, the same group had reported an incidence of 16.5% in a group of 30 TURBT's. (25) Tatlissen et al had a rate of 55.3% in a series of 114

TURBT's in lateral wall tumours, 97% of which were successfully eliminated by the use of an obturator nerve block. (26) In the study by Deliveliotis et al, over 20% of cases had such significant adductor nerve stimulation that it led to abandonment of the procedure and incomplete resection of the tumour. (27) Prentiss et al published similar findings, with a 20% rate of adductor muscle contraction during the resection of lateral wall tumours and intra-prostatic adenomas. (28)

There are number of technical modifications performed by the surgeon in order to reduce the incidence of the obturator jerk. Bladder filling can be controlled, so as not to over-distend and thin out the bladder wall. (6,15,27) Placement of the inactive electrode at a longer distance from the resectoscope has been claimed to reduce the incidence of obturator jerk, (15) as has the resection of smaller chips. (27) One of the newer technical modifications which is claimed to reduce the incidence of the obturator jerk is the use of the bipolar system for resection. Among the earliest papers to lay this claim is the one of Shiozawa et al, who resected the bladders of 4 pigs using the bipolar system. (20) They observed no stimulation of the obturator nerve during these resections except for a "weak creeping of the lower limbs" during resection 1cm below the ureteric orifice. They attributed this to the fact that the current passes to the inactive electrode in the sheath of the bipolar system, thereby avoiding passage of the high frequency current through the body of the patient. The current also gets dissipated via a wide arc because of the use of normal saline, thereby reducing nerve stimulation. (20)

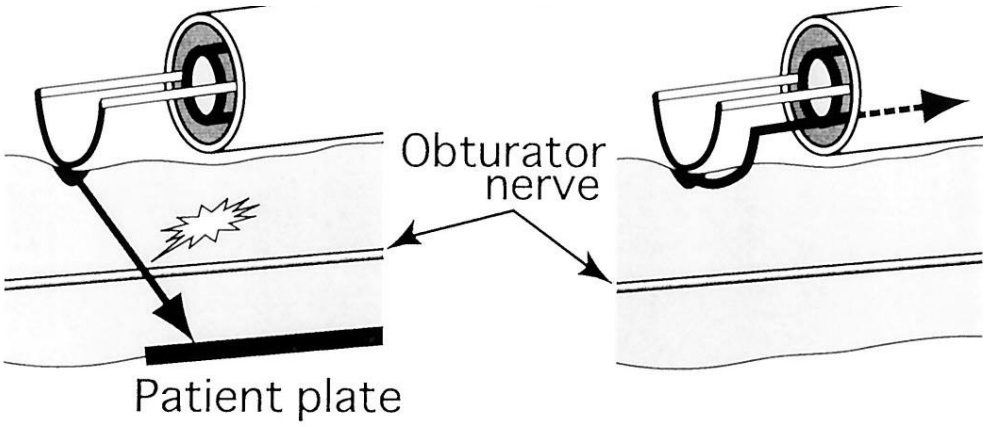


Fig. 8: How bipolar current could prevent obturator jerk

Xishuang et al compared TURBT using the convention monopolar system, the plasmakinetic bipolar system and Holmium laser TURBT. They observed obturator jerks in 16% of cases using the monopolar system, but in none of the cases using the other 2 systems. (29) Pu et al reported long-term results of 121 cases that underwent TURBT using the bipolar system. They reported a rate of 4.9% for the obturator jerk. (30)

Gupta et al also reported on the results of the bipolar system. (31) In the initial 10 cases, in which they used settings of 160Watts (W) and 80W for cutting and coagulation respectively, they observed obturator jerk in 30% cases. They subsequently reduced the settings to 50W and 40W and observed no obturator jerk in the subsequent 98 cases. (31) Puppo et al reported obturator jerks in 2% of 480 TURBT's using the bipolar system. (32) However the location of tumours and anesthesia used is not detailed in their study. They state that they doubt the bipolar system can eliminate obturator jerks because current transmission does occur for few millimetres, even with this system. (32) Kitamura et al have reported bladder

perforation secondary to obturator jerk in a patient using the bipolar system and suggest that traditional surgical and anesthetic precautions must be taken even when using bipolar cautery. (33) Brunken et al observed no obturator jerks in a series of 35 bladder tumour resections. (34) Geavlette et al also showed lower stimulation of the obturator nerve using the bipolar system (3.2% vs 18.6%). (35) However, the anesthesia used for the resections is not specified in their paper.

Anesthetic techniques to reduce obturator jerks are probably more successful than any surgical options. General anesthesia with the use of muscle paralysis is the most efficient and is recommended by some authors for routine use in lateral wall tumours, especially large ones. (6,14) Muscle relaxation using succinyl choline has been shown to be a fast acting and cost-effective approach. (36)

Blockade of the obturator nerve using local anesthetic has been described as an effective technique to reduce or even eliminate obturator jerks. Traditionally it was performed using fixed anatomical landmarks and had a low, but finite, failure rate. (25,26,37) The obturator nerve can be localized using a nerve stimulator allowing a near perfect block which practically eliminates the incidence of obturator jerk. Gasparich et al described 275 cases over 2 years in whom there was no obturator jerk with the use of the nerve stimulator. (38) Khorrami et al have described the obturator nerve block using a transvesical cystoscopic approach and report rates of obturator jerk of 3-6%. (24,25) They suggest that this technique is effective and should be performed by the urologist themselves, thereby reducing time required for blockade.

Thallaj and Rabah performed a study of ultrasound-guided nerve block. They were successful in 97.2% cases and required an average of only 4.3 minutes per side for performing a block. (39)

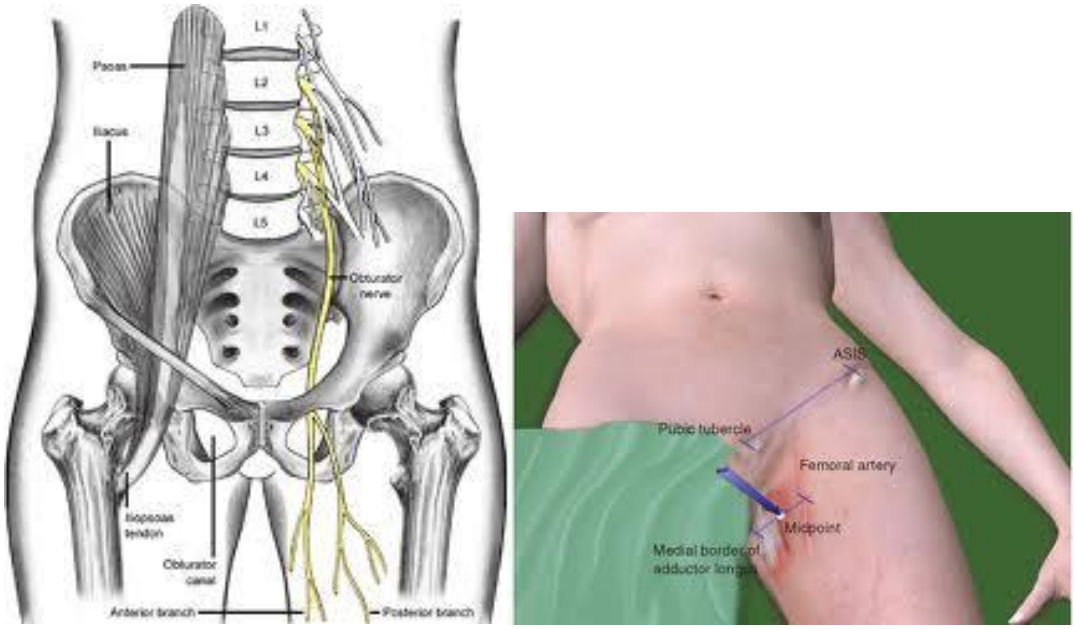


Fig. 9: Course of the obturator nerve and landmarks for obturator nerve block

Pathological analysis and 'quality' of TURBT:

The WHO recommends the use of the term 'urothelial cancer' as opposed to the more widespread 'transitional cell carcinoma'. (6) The current classification of grade has been accepted by both urologists and pathologists. Malignant neoplasms are classified as ***low-grade*** and ***high-grade*** depending on the nuclear and cellular architecture, a change from the prior system of grading from 1 to 3. (40) Grade, not stage, is the most important predictor of progression, and low-grade and high-grade tumours can be regarded as distinct diseases with respect to tumour biology, genetic origin and ultimately management. (6) All ***carcinoma-in-situ (CIS)*** is considered high-grade and generally presents as a flat, velvety lesion with severe dysplastic changes that is confined to the epithelial layer. It should not be considered premalignant, but as a precursor to invasive malignancy, as 40-83% will ultimately develop invasive malignancy if untreated. (1,6,40)

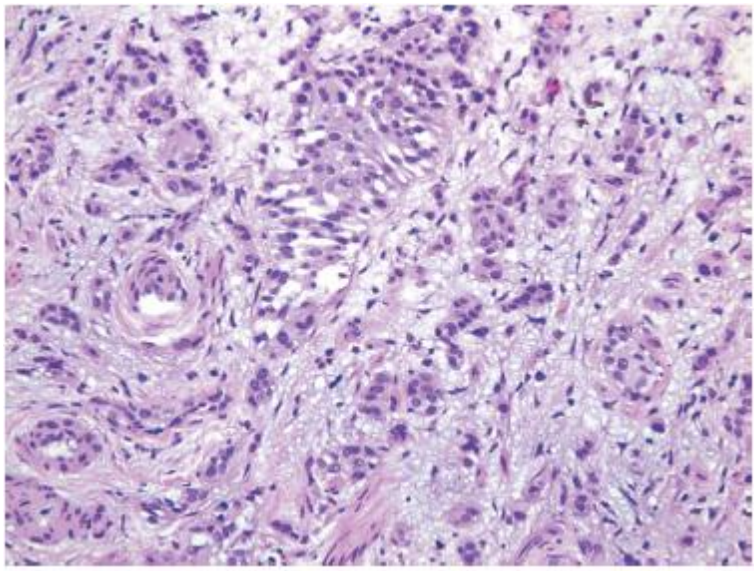


Fig. 10: High grade disease showing disordered cellular architecture with extensive nuclear pleomorphism

Papillary urothelial neoplasms of low malignant potential (PUNLMP) is a new category that was added to represent the grade 1 tumours of the previous classification. (40) It consists of essentially benign papillary growths with orderly cellular architecture that have a propensity to recur, but a very low probability to progress to invasion. (6)

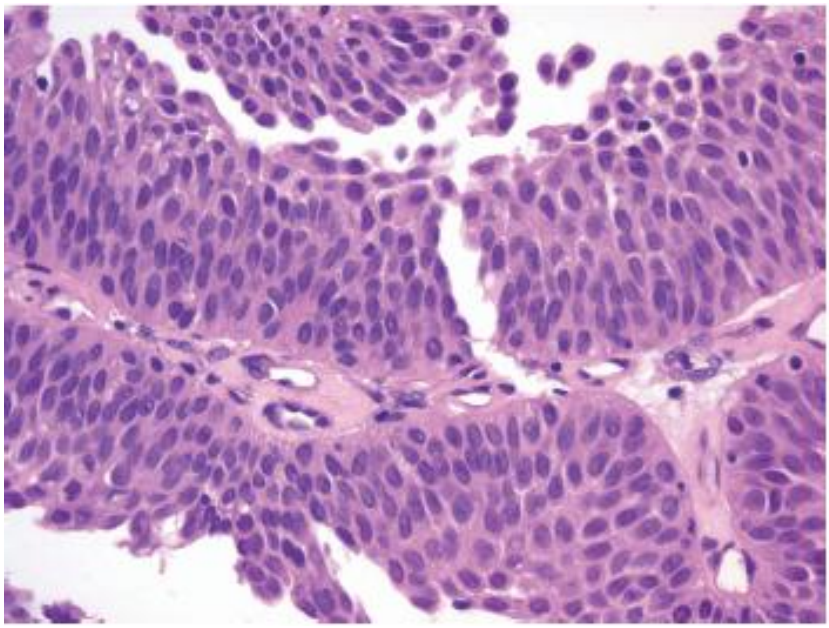
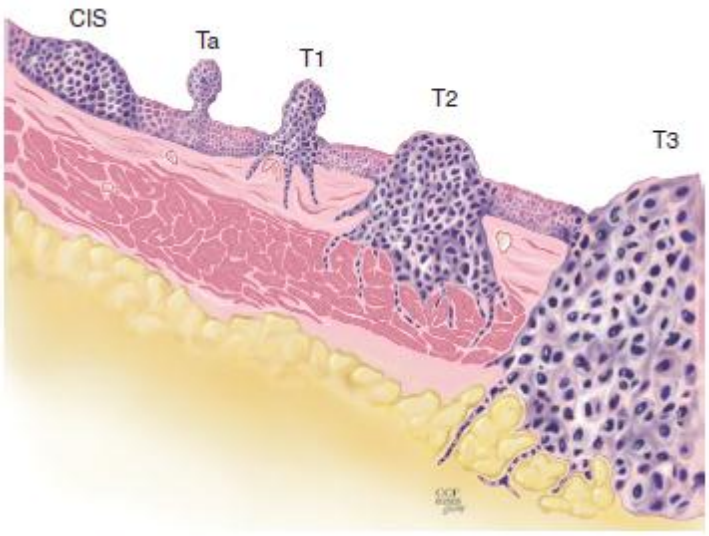


Fig. 11: PUNLMP showing orderly arrangement of cells with minimal atypia or nuclear pleomorphism

The ***TNM system*** is used for pathological staging of the disease. Ta includes tumours that are confined to the epithelial layer and is generally considered non-invasive. However, it may include both low and high-grade tumours. (1,6) T1 refers to disease that has invaded the lamina propria, and is often termed non-invasive, though this is not strictly accurate. (6) The lamina propria contains the muscularis mucosae, a thin layer of muscle, and tumour cells seen in context to this layer may be misinterpreted as muscle invasive. T2 disease refers to invasion of the detrusor muscle and is

associated with need for radical cystectomy if non-metastatic.(6) T3 disease refers to extravesical spread and T4 disease involves adjacent organs like the prostate and seminal vesicles



Ta – Confined to epithelium

T1 – Invades lamina propria

T2 – Detrusor invasion

T3 – Extravesical spread

T4 – Invasion of adjacent organs

Fig. 12: Pathological staging of urothelial cancer

Pathological analysis of the chips obtained at TURBT is the backbone of grading and staging of disease, and remains the basis on which further management is based. The quality of TURBT therefore is an important variable that needs to be assessed when determining optimal management. Due to the piecemeal technique of resection in TURBT, limitations exist in determining the quality of a TURBT. (5) In a TURBT only grossly visible tumour is resected and there is no concept of a safe margin, hence it remains impossible for the pathologist to comment on the completeness of resection. (5) Similarly, the TURBT technique compromises the ability of the pathologist to comment on the exact stage as the pathologist has to piece together the picture like a jigsaw puzzle, and under-staging remains a significant problem. (5,6)

Herein lies the need for excellent communication between the pathologist and the urologist in order to minimize errors.

As a result of these difficulties, a number of other markers have come into use as surrogates to grade the quality of resection. The major pathological criterion determining quality of resection is the ***presence of 'deep muscle' or detrusor*** in the TURBT sample. (5) It is standard practice to resect muscle in the tumour bed and send it separately for pathological analysis. (6) The absence of this muscle seriously compromises the pathologists' ability to accurately stage the depth of invasion, with double the risk of under-staging as compared to specimens with deep muscle. (6) Absence of deep muscle can thus be considered an incomplete TURBT.

Repeat TURBT is indicated in a number of situations. The most obvious would be an inability to completely resect the tumour at the first sitting. This may be due to large tumour bulk, inaccessible locations, bladder perforation or medical condition of the patient necessitating the premature termination of the procedure. (6) In patients with T1 tumours repeat resection demonstrates worse pathological findings in up to 25% cases, (6) and residual tumour in up to 75%. (41) Therefore the current recommendations for repeat TURBT for T1 and high-grade Ta tumours came into practice. Markers for quality of the original resection at the repeat TURBT would therefore include presence of gross residual disease, under-staging following repeat TURBT (which is in the range of 18 to 37% for high-risk tumours) and presence of T1G3 on repeat resection. (5,6)

Recurrence is a common complication of bladder tumours and occurs in 50-70% of cases. (7) While tumour biology and field change are definitely causative factors, incomplete resection and tumour cell implantation following TURBT also contribute

to this. (7) Differences in TURBT technique among institutions as well as individual surgeons have been shown to affect recurrence rates. (42,43) Therefore the recurrence rate at the first follow-up cystoscopy becomes another surrogate marker of the quality of TURBT. (5)

A number of techniques are growing in popularity with respect to improving the quality of TURBT. (7) The use of a photodynamic agent followed by cystoscopy using blue light allows increasing sensitivity in the detection of tumours. This is true for both papillary tumours as well as for CIS. (5) It also helps identify the margins of a tumour more distinctly thereby allowing more complete resection. It has been shown to reduce the risk of residual tumour and also increases progression free survival. (44)

Early repeat TURBT at 3-6 weeks following initial resection for specific indications as discussed above also minimized under-staging. (6)

The role of random biopsies remains controversial as no data exists that convincingly proves any benefit. They are definitely not indicated in low-risk patients but may be considered in cases of multiple tumours or patients with positive urine cytology. (6)

Bipolar cautery is an alternative that seems to hold promise in improving the quality of resection as it allows resection in normal saline. The pathological sample obtained has been shown to be equivalent to that by monopolar current, (45–47) and some consider it better because it causes less charring of tissue. (5)

Laser resection of bladder tumours has also been described. Holmium Laser is preferred due to its controlled depth of penetration. (7) It is said to have improved hemostasis, and allows resection in saline as well as the possibility of en-bloc

resection. (48) A possible application is the outpatient use of laser fulguration of recurrent low-grade papillary tumours under local anesthesia using the flexible cystoscope. (49)

Ultimately, surgeon experience with adequate training and initial performance under supervision would be useful, as surgeon factors are known to affect the completeness of TURBT. (5)

Role of and literature regarding bipolar TURBT:

Bipolar resection has been conclusively documented as an excellent alternative in transurethral resection of the prostate (TURP). It allows the performance of resection in normal saline thereby allowing a longer duration for the procedure, which is especially useful in large prostates. Freedom exists for the surgeon knowing there is almost no possibility of fluid or electrolyte abnormalities secondary to irrigant absorption. (11) During bipolar resection coagulation occurs simultaneously with cutting, allowing controlled resection with better hemostasis and lower transfusion rates. (5,11) Charring of tissues is also less, thereby allowing better pathological examination of tissue. (5) The ability to carry on resecting for a longer duration allows better resident training and less hurried teaching of the challenging technique of TURP. (11) Other parameters of safety and effectiveness of resection have matched the traditional monopolar resection and created a definite place for bipolar TURP in the urologists' armamentarium.

With such evidence backing for TURP, it was natural that attention would be turned to the bipolar system for TURBT. Initial studies were promising with purported advantages of reduced obturator jerk and bladder perforation, in addition to those mentioned for TURP. (20) However no high-level evidence comparing both modalities exists. This coupled with the fact, that TUR syndrome is extremely rare in TURBT means that the exact role of bipolar TURBT remains undefined at present.

Shiozawa et al first modified the traditional monopolar cautery by placing the return electrode along the outer sheath of the resectoscope. (20) This was a pseudo-bipolar system termed transurethral resection in saline (TURis). They conducted a study on 4 porcine bladders by resecting a total of 8 sites per bladder using this system – ureteric

orifice, 1 and 2cm supero-lateral to the orifice, and 1cm below the orifice. The TURis system was compared with the traditional monopolar system. The authors found 1 strong and 2 weak adductor muscle contractions using the conventional system versus only 1 weak contraction using the new system. They believed that placing the return electrode within the resectoscope sheath allowed only minimal transmission within the body, thereby reducing stimulation of the obturator nerve. They also observed that due to the smaller loop used, chips using the TURis system were smaller but there were no histological differences. (20)

Subsequently, Brunken et al published their experience with TURis system in 35 patients with bladder tumours. (34) Surgeon assessment of the system was documented. They showed that no extra training or experience was required to use this system. Surgeons were satisfied with the cutting ability of the loop, and the lack of charring at the site of resection allowed excellent assessment of the resected area once the chip was disconnected. They observed no instance of obturator jerk in these 35 cases, and there was no difference in the quality of specimen obtained for pathological examination.

In 2008, Pu et al reported long-term results on 121 resections of superficial bladder tumours. (30) They used the Gyrus Plasma-kinetic Tissue Management System with setting of 160W and 80W for cutting and coagulation respectively. Fifty-five percent of tumours were on the lateral wall and over 70% were low-grade tumours. The mean size of tumour was 1.9cm. Blood transfusion was required in 3 cases and bladder perforation occurred in 2 cases (both were managed conservatively). No case of electrolyte imbalance was observed. They had a 5-year recurrence free rate of 45.5% and a stricture rate of 4.1%. They observed adductor muscle contraction in 6 cases, one of which was severe enough to lead to a bladder perforation. The use of different

modes of anesthesia is a limitation of their study and is relevant to the incidence of obturator jerk. They believed that the mechanism of this contraction needs further investigation, as there is no theoretical basis for its occurrence with the bipolar system. (30)

Puppo et al reported on 1000 cases of resection performed with TURis, of which 480 were for bladder tumours. (32) They excluded patients who underwent radical cystectomy within 6 months of the TURBT from further analysis. Forty-two percent of cases had multiple tumours, and 63% had at least one tumour on the lateral wall. There was no case of TUR syndrome in their entire cohort. The median drop in hemoglobin in their study was 0.7mg%. Ten cases (2%) developed clot retention post-operatively, and 4 (0.8%) required transfusions. Obturator nerve stimulation was observed in 2% of lateral wall tumours. They believed that despite the bipolar system, current does get transmitted through the bladder wall for a certain distance, and obturator nerve stimulation cannot be eliminated using this. In women, and those with thin bladders, this could pose the same risk as monopolar cautery. (32) The concern with this system was the possibility of increased urethral strictures secondary to the passage of current through the penis and urethra. (50) However, Puppo et al had a stricture rate of 2.5%, which is comparable with traditional methods. (32)

Gupta et al reported their experience of the Gyrus Plasmakinetic Tissue Management System in 98 TURBT's. (31) They used settings lower than the recommended – 50W for cutting and 40W for coagulation. This was because in the initial 10 cases with standard settings they had 3 cases of obturator jerk with 2 bladder perforations. The mean tumour size was 2.5cm, with 63% having multiple tumours, and 69% involving the lateral wall. The mean drop in hemoglobin was 0.94mg%, and 5 patients required blood transfusion. There was no instance of TUR syndrome and complete resection

was achieved in 96% cases. They reported no cases of obturator jerk or bladder perforation with the low power settings and hence believe that the default factory settings are probably too high. Their hypothesis was that the initial high voltage needed to generate plasma could be responsible for transmission of current through the body, with resultant stimulation of the obturator nerve. In their experience, generation of plasma was effective even at low voltage settings with no hindrance to cutting or coagulation. They too found that visualization of the resected area was better with the bipolar system as there was no blackening of tissue. They had 18 cases of coronary artery disease, 6 patients with pacemakers, 1 with dilated cardiomyopathy and 2 patients with a recent history of non-ST elevation myocardial infarction in their series. They were able to safely complete resection in all these patients and believe that the bipolar system may offer an advantage in this category of patient, as fluid and electrolyte fluctuations are negligible. (31)

Xishuang et al reported their experience with 173 TURBT's performed at their institution. (29) Fifty-one cases underwent monopolar TURBT, 58 cases underwent bipolar TURBT and 64 patients underwent resection using Holmium laser (en bloc resection was carried out as far as possible). For the bipolar plasma-kinetic system, settings of 120W and 60W were used for cutting and coagulation, respectively. The 3 groups were well-matched with respect to patient and tumour characteristics. About 40% of tumours were on the lateral wall. There was no case of TUR syndrome in any group. More post-operative irrigation was required in the monopolar group ($p<0.01$). Catheterization and hospitalization time were also significantly longer in the monopolar group ($p<0.01$). Obturator jerk and bladder perforation were seen in 8 and 4 cases respectively, in the monopolar group, but in none of the other 2 groups. This result was also statistically significant ($p<0.01$). They attributed this to the fact that a

far lower temperature was required for cutting using the bipolar system (40 to 75 °C), as opposed to the monopolar system (100 to 300 °C). These authors also claim better hemostasis using the bipolar system. Sticking of TURBT chips to the resectoscope loop was not seen using the bipolar system. Interestingly, there was no reduction in the 2-year recurrence free rate despite the en-bloc resection performed using Holmium laser.

Geavlette et al recently published a study in which they randomized patients with bladder tumours larger than 3cm to two groups. (35) The study group underwent resection using narrow-band imaging (NBI) cystoscopy and bipolar cautery. The control group underwent resection using traditional white-light cystoscopy and monopolar cautery. Both groups were well matched for baseline variables. Ninety-five patients were analysed in the bipolar group, and 97 patients in the monopolar group. Obturator jerk occurred in 3 cases in the bipolar group versus 18 in the monopolar group ($P<0.001$). Bladder perforation was also significantly less common in the bipolar group (1.1 vs 7.2%, $p=0.03$). However, the anesthesia used in their study has not been mentioned. The authors also demonstrated a significantly lower fall in hemoglobin (0.2 vs 0.9 gm%, $p<0.0001$) in the bipolar group, as well as a shorter duration of hospital stay and catheterization period in this group ($p<0.0001$). The transfusion rates, rates of post-operative bleeding requiring re-coagulation and instances of TUR syndrome were not significantly different among both the groups. With reference to the use of NBI cystoscopy, the study showed a significantly lower residual tumour rate, primary site recurrence rate and 1-year recurrence rate in the study arm. They conclude that NBI and bipolar TURBT are an excellent alternative to the traditional method of TURBT and have the potential to improve on the current standards.

Kitamura et al reported a case with bladder perforation and bleeding secondary to obturator nerve reflex in a resection using the TURis system. They believe that it is necessary to take all standard precautions to prevent obturator jerk even when using bipolar resection. (33)

Lee et al reported the successful resection of a bladder tumour in a gentleman with an implanted cardioverter defibrillator, without prior deactivation of the device. (47) They believe this system would be useful in this high-risk group of patients.

As discussed, pathological analysis of the TURBT chips is the cornerstone for management of the disease. There was initial concern that due to the smaller size of the chips obtained using the bipolar system, pathological analysis could be compromised. (20) Lagerveld et al compared specimens in 9 bipolar resections (Gyrus plasma-kinetic system) with 16 cases resected using the conventional monopolar cautery. (45) They postulated that larger loops have less contact time with tissue and should cause less thermal artifact. A slower velocity of resection will cause a larger contact time and therefore more artifacts. They also believed that tissues with higher water content like epithelium and lamina propria, were more susceptible to thermal artifact. In bipolar resection smaller loops are used and contact time could be prolonged with the possibility of greater thermal artifact. The authors measured the depth of the thermal-mechanical artifacts in 10 fields using a morphometric system. They found no significant difference in this measurement and concluded that both systems were equivalent with respect to the quality of tissue obtained.(45)

Wang et al performed bipolar resection in 11 patients using the plasma-kinetic system and compared them with an equal number who had undergone monopolar TURBT. (46) They defined severe artifact as the majority of TURBT chips having >50%

cautery artifact. The pathologist was blinded to the cautery that was used for resection. Severe artifact was seen in 36% cases in the monopolar group and 55% in the bipolar group. This was not statistically significant, owing to the small sample size. Importantly, the pathologist had no difficulty in interpreting specimens from either group, and deep muscle could be identified in all bipolar resections. (46)

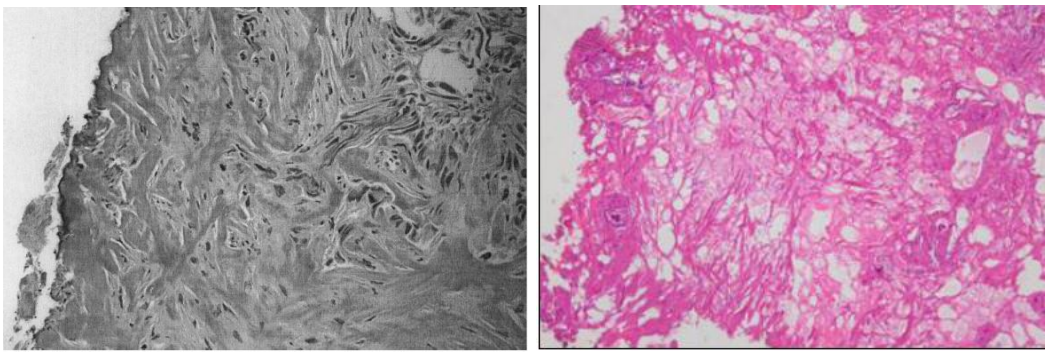


Fig. 13: Specimens with severe cautery artifact

Yang et al retrospectively compared the specimens obtained in 64 bipolar resections with those in 51 monopolar TURBT's. (51) A single pathologist graded all specimens. Cautery artifact was categorized as grade 1 if it involved less than one-third of the specimen, grade 2 if it involved one-third to to-thirds and grade 3 if more than two-thirds was involved. The depth of the deep muscle obtained in the bipolar group was significantly less than the monopolar group ($p<0.001$). However there was no significant difference among the different grades of cautery artifact, and the pathologist was confident of making a diagnosis in all cases.(51)

All this literature seems to suggest that, at the least, bipolar TURBT is equivalent to the traditional monopolar cautery. There are also could be certain advantages to the use of the bipolar system, for example, in high-risk cases, and possibly to reduce the risk of obturator jerk. However in the absence of a well-designed randomized control trial to address this issue, the exact role of bipolar TURBT remains unknown.

Material and methods

Design and duration of study:

A single-centre parallel arm randomized controlled trial was designed and carried out at our institution from May 2011 to August 2012.

The allocation ratio used was 1:1 to ensure an equal distribution among both monopolar and bipolar arms.

The approval of the Institutional Review Board and Ethics Committee was obtained. The trial was registered with the Clinical Trial Registry of India (***CTRI number: CTRI/2011/06/001785***).

Consolidated Standards of Reporting Trials (CONSORT) guidelines have been used to report all aspects of the trial. (52)

Inclusion criteria:

All patients undergoing TURBT for suspected bladder tumours were eligible for inclusion.

Exclusion criteria:

- Restaging TURBT's for high-grade bladder cancer were excluded.
- Patients refusing to participate.
- Patients unfit for spinal anesthesia.
- Patients who required simultaneous procedures (for example transurethral resection of the prostate, ureteroscopy, etc.).

Spinal anesthesia was used for all cases, and patients had to be passed fit for the same by an anesthesiologist. No obturator block was used. The department of

Anesthesiology was informed prior to starting the study and had no objections to the performance of the study.

An information sheet was provided to all patients and those who consented to take part were included for randomization.

Bipolar resection was carried using the Gyrus-AMCI ^{TM} Plasma-kinetic Superpulse generator. The settings used were 100W for cutting and 80W for coagulation. Resection was carried out using a thin Plasmakinetic Superloop. Normal saline was used as irrigant.

(a) **(b)**

Fig.14: (a) Gyrus-ACMI^{TM} Plasmakinetic Superpulse Generator

(b) Plasmakinetic Superloop.

(Images Courtesy Gyrus ACMI Systems.)

Monopolar resection was performed with a Storz Vaporcut (4mm) resection loop 1.5% Glycine was used as the irrigant for all these resections.

All resections were carried out in a standard fashion. The tumours were resected from the periphery to the centre. The stalk of the tumour was resected last, and an, additional sample of deep muscle from the base of the tumour was obtained in order

to determine depth of invasion. Coagulation was achieved using the loop in the bipolar system, and a combination of loop and roller-ball cautery for the monopolar system.

Being a teaching institution, both consultants, as well as senior residents under the supervision of a consultant, were involved in performing the surgeries. The name and experience (resident/ consultant with up to 3 years' experience/ senior consultant) of each surgeon was noted.

Outcomes:

The primary aim was to assess the safety and efficacy of bipolar TURBT in comparison with the current standard of monopolar resection. The most important outcomes assessed were the incidence of obturator jerk and bladder perforation. Secondary outcomes assessed included:

- Difference in pre-operative and post-operative hematocrit
- Need for blood transfusion
- Clot retention and need for bladder wash/ re-coagulation
- Difference in pre- and post-operative sodium values
- Development of TUR syndrome
- Resection time

Specimen quality was assessed by a single examining pathologist documenting the degree of cautery artifact in the specimen, in addition to determining the presence of deep muscle in the sample.

Outcome definitions:

- *Tumour size* referred to intra-operative visual assessment of the size as determined by the surgeon in relation to loop width.
- *Obturator jerk* referred to adductor muscle contraction leading to a jerk of the ipsilateral thigh, during resection of lateral wall tumours.
- *Bladder perforation* was defined intra-operatively by the visual appearance of extravesical fat, bowel or peritoneal cavity. Post-operatively, bladder perforation was said to have occurred in cases with progressive abdominal distention, suprapubic tenderness and signs of peritonitis.
- *Hematocrit value* was measured 48 hours post-operatively in order to overcome dilutional effects. The difference between pre-operative and post-operative values, as well as transfusion requirements between the 2 groups was used to determine any difference in blood loss.
- *Clot retention* was defined as any episode of post-operative urinary retention associated with hematuria, and due to the presence of blood clots in the bladder as noted on ultrasound. The need for bladder wash and cystoscopy with fulguration of bleeders was noted.
- *Serum sodium* was measured at 12 hours post-operatively and symptoms of hyponatremia, if any, including headache, visual disturbances, altered sensorium and hiccups were documented.
- *Resection time* was defined as the time between the start of resection and removal of the device.
- *Completeness of resection* was assessed by presence of muscle in the specimen (as determined on histopathological examination) and absence of gross residual tumour after surgery.

- *Severe cautery artifact* is defined as a majority of TURBT chips from a patient with epithelium having >50% cautery artifact. (46)
- *Gross residual tumour* referred to the surgeon's assessment at the end of the procedure as to whether any tumour was left behind.

Sample size calculation:

A target sample size of 49 events per arm was calculated using 80% power and 95% significance level for the obturator jerk (alpha error 5%). This was carried out assuming an average incidence of obturator jerk of 25% for the monopolar system, and 5% for the bipolar system for lateral wall tumours. These incidences were arrived at after a comprehensive literature review for these statistics.

$$n = \frac{2(\bar{p})(1-\bar{p})(Z_{\beta} + Z_{\alpha/2})^2}{(p_1 - p_2)^2}$$

- Power = 80%
- α-error = 5%
- p_1 = 0.25 (Incidence of obturator jerk using monopolar cautery)
- p_2 = 0.05 (Incidence of obturator jerk using bipolar cautery)

No interim analysis of the data was carried out.

Randomization technique:

Patients were randomized to either the monopolar or bipolar arm using the block randomization technique. Each block contained 10 cases and was generated by the principal investigator using a computer program.

Allocation concealment and blinding:

The allocation was concealed in sealed envelopes and the operating room technician implemented the randomization. The surgeon involved in performing the procedure was unaware to which arm the patient had been assigned till the patient was on the operating table.

Patients were blinded as to which arm they were allocated.

The pathologist analyzing the samples was blinded to the procedure performed. A single central pathologist analysed all the samples.

The statistician analysing the data was blinded to both groups.

Statistical analysis

Statistical analysis was performed using Statistical Product and Service Solutions (SPSS®) version 16 (IBM Corporation, USA).

Mean ± standard deviations were used for normally distributed data and median & range (min – max) was used for skewed data to avoid the outlier effect.

Significance was determined using the independent sample t-test for quantitative variables; and the chi-square test for qualitative data.

Intention-to-treat analysis of all patients who were randomized was performed.

Per-protocol analysis of both groups was performed after excluding patients in whom there were significant protocol violations. These violations included inadvertently giving the patient general anesthesia, or the performance of additional procedures like ureteroscopy.

PROFORMA

MONOPOLAR VS BIPOLAR RESECTION OF BLADDER TUMOURS

STUDY NUMBER: _____

(A) Patient Details:

Name: Hospital Number:
Age: Sex:
Address:

Comorbidities:
ASA Grade:
Smoker:
Diagnosis:
Pre-op PCV:
Pre-op Sodium:

(B) Characteristics of Tumour on Cystoscopy:

Number:

Size:

Papillary or Sessile:

Size of stalk/ base:

Primary or recurrent:

Location:

(C) Operative Events:

Surgeon:

Monopolar or Bipolar:

Anesthesia:

Resection time:

Incidences of Obturator Jerk:

Bladder Perforation:

Gross Residual Tumour:

Conversion to GA:

(D) Post-operative:

Quantity of saline used for irrigation:

Hemoglobin/ PCV at 48 hours:

Need for Transfusion:

Clot Retention:

Serum Sodium at 12hours:

Signs of Bladder perforation:

- Fever
- Abdominal Pain
- Abdominal distention / Ileus

(E) Pathological Specimen:

Presence of muscle in the sample:

Grade:

Stage:

Degree of Cautery Artefact:

(F) Follow-up:

Urethral Stricture:

(G) Miscellaneous:

Results

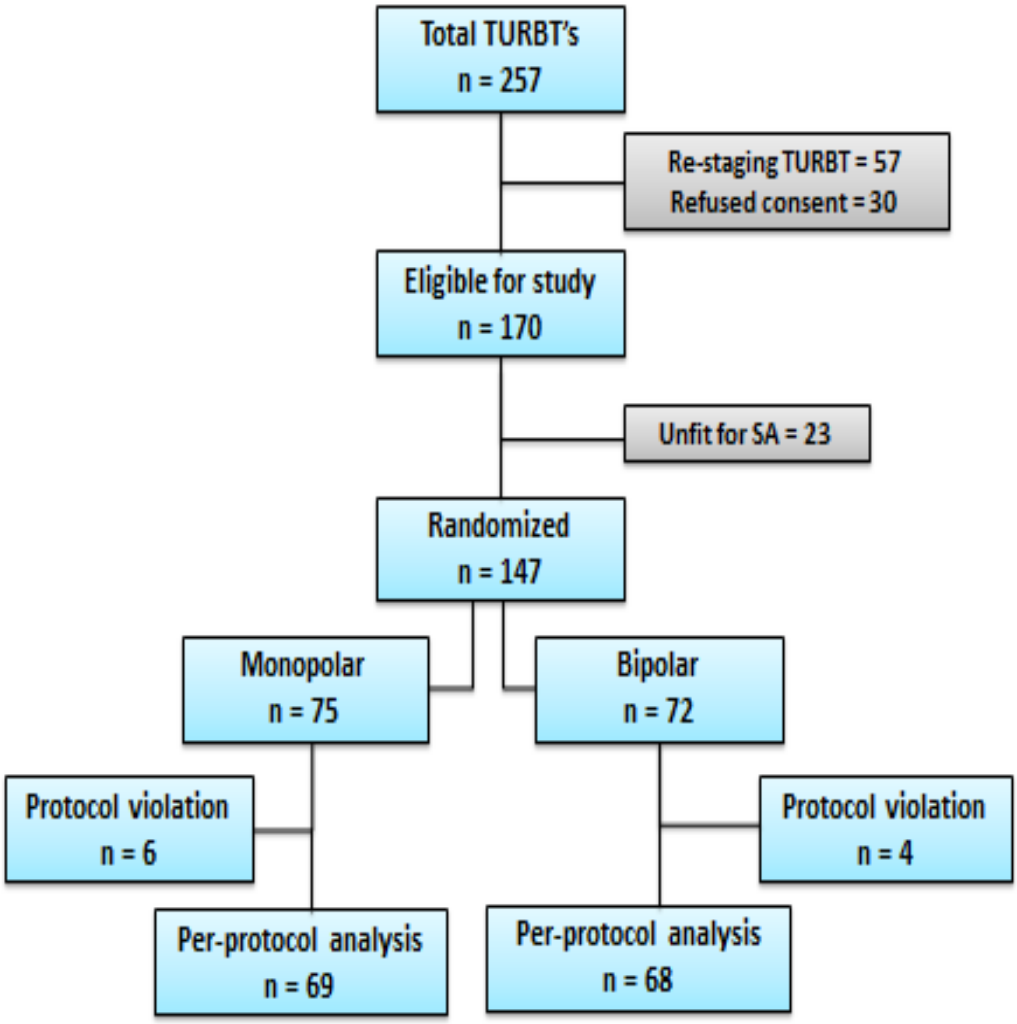


Fig. 15: Consolidated Standards of Reporting Trials (CONSORT) diagram. TURBT = Trans-urethral resection of bladder tumour. Protocol violations have been detailed in the text

A total of 257 TURBT's were performed during the duration of the study. Restaging TURBT's excluded were 57 in number. Thirty patients refused to participate in the trial.

Of the remaining 170 patients, 23 were deemed unfit for regional anesthesia and were excluded. The remaining 147 cases were randomized into the monopolar or bipolar arms. Of these cases, 6 patients in the monopolar arm and 4 in the bipolar arm were excluded from intention-to-treat analysis as they underwent a breach of protocol. This took the form of a simultaneous additional procedure like TURP or ureteroscopy; or being inadvertently given general anesthetic by the anesthesiologist. As a result 69 cases in the monopolar arm and 68 in the bipolar arm were eligible for per-protocol statistical analysis. The initial distribution of 75 in the monopolar arm and 72 in the bipolar arm underwent intention to treat analysis.

The demographic characteristics of the patients are shown in Table 1. The mean age of patients was 55.13 years and only 9 cases were female. As expected, the majority of the cohort was smokers. Diabetes and hypertension were the most common associated comorbid illnesses, being seen in over 43% of the patients.

Table 1 – Demographic data (N = 147)	
Mean age (years) (SD)	55.3 (12.4)
M:F	136:9
ASA grade • I • II • III	 77 67 3
Smokers	63.9%
Comorbid illness • Nil • Diabetes • Hypertension • Both • COPD • Others	 78 25 21 15 4 4

The average number of tumours was 2.24 per patient. Eight-five cases had a solitary tumour. The average tumour size was 2 X 1.75cm. The lateral wall was the commonest location accounting for 50% of cases in isolation, and another 25% in association with other sites. Over 25% of tumours were muscle-invasive on biopsy, while 60% were high-grade. Tumour characteristics are detailed in Table 2. Miscellaneous pathological diagnoses obtained included cystitis cystica, inverted papilloma, nephrogenic adenoma, endometriosis, etc.

Table 2 – Tumour Characteristics (N=147)	
Average number per patient	2.24
Average size per tumour (cm)	2 * 1.75
Morphology • Papillary • Sessile	 57 90
First occurrence in patient Recurrent tumour	51 96
Location • Lateral wall • Multicentric incl lateral wall • Trigone • Multicentric excl lateral wall • Posterior wall • Dome	 75 39 8 8 6 6
T-stage • CIS • Ta • T1 • T2 • Misc	 1 43 49 38 16
Grade • 1 • 2 • 3 • Misc	 25 15 88 16

Both arms were well matched with respect to demographic characteristics and tumour factors [Tables 3 and 4]. There was also no significant difference with respect to the experience of the surgeon performing the resection [Table 3].

Table 3 – Baseline demographic variables

	Monopolar	Bipolar	p
n	**75**	**72**	
Mean age (SD)	55.5 (12.5)	55.2 (12.4)	0.99
Sex: Male (%)	70 (93.3)	68 (94.4)	0.99
ASA: (%) • I • II • II	 39 (52) 34 (45.3) 2 (2.7)	 38 (52.7) 33 (45.8) 1 (1.4)	 0.87
Smoking (%)	46 (61.3)	48 (66.7)	0.47
Co-morbidities (%) • None • HTN • DM • Both • COPD • Misc	 36 (48) 17 (22.7) 10 (13.3) 7 (9.3) 2 (2.7) 2 (2.7)	 42 (58.3) 8 (11.1) 11 (15.3) 8 (11.1) 2 (2.8) 1 (1.4)	 0.44
Surgeon (%) Resident Junior consultant Senior consultant	 20 (26.7) 44 (58.7) 11 (14.7)	 20 (27.8) 35 (48.6) 17 (23.6)	 0.43

Table 4 – Baseline tumour variables			
Tumour Characteristic	**Monopolar**	**Bipolar**	**p**
n	**75**	**72**	
Mean number (SD)	1.97 (1.69)	2.51 (3.21)	0.21
Mean Length (SD)	4.55 (3.52)	4.38 (3.97)	0.79
Mean Breadth (SD)	3.90 (3.1)	3.90 (3.82)	0.99
Sessile (%)	41 (54.7)	49 (68.1)	0.13
Recurrent (%)	46 (61.3)	50 (69.4)	0.39
Location (%) • Lateral wall • Trigone • Dome • Posterior wall • Multicentric incl lateral wall • Multicentric excl lateral wall	 37 (49.3) 7 (9.3) 2 (2.7) 3 (4) 22 (29.3) 4 (5.3)	 38 (52.8) 6 (8.3) 4 (5.6) 3 (4.2) 17 (23.6) 4 (5.6)	0.69
Tumour stage: (%) • pTa • pT1 • pT2 • CIS • Misc	 22 (29.3) 23 (30.7) 21 (28) 0 (0.0) 9 (12)	 21 (29.2) 26 (36.1) 17 (23.6) 1 (1.4) 7 (9.7)	0.76
Tumour grade: (%) • 1 • 2 • 3 • Misc	 13 (17.3) 8 (10.7) 45 (60) 9 (12.0)	 12 (16.7) 7 (9.7) 43 (59.7) 7 (97)	0.91

The results of the intention to treat analysis are summarized in Table 5. The incidence of obturator jerk in each arm was over 50% in lateral wall tumours (n = 59 for monopolar arm and n = 55 for bipolar arm) with no significant difference noted between both arms. Bladder perforation occurred in about 16% in both arms.

The mean drop in haematocrit was not statistically different between the two arms. Four patients in the bipolar arm required transfusion, as opposed to one patient in the monopolar arm. Similarly, four patients in the bipolar arm developed clot retention and needed re-coagulation in theatre; as opposed to 3 in the monopolar arm. These results were not statistically significant.

The reduction in post-operative sodium was less in the bipolar arm (mean change 1.97 vs 1.17 mmol/L) and there was no instance of TUR syndrome. However this result did not reach statistical significance due to the rarity of the event itself. The study was underpowered to detect significance of this observation.

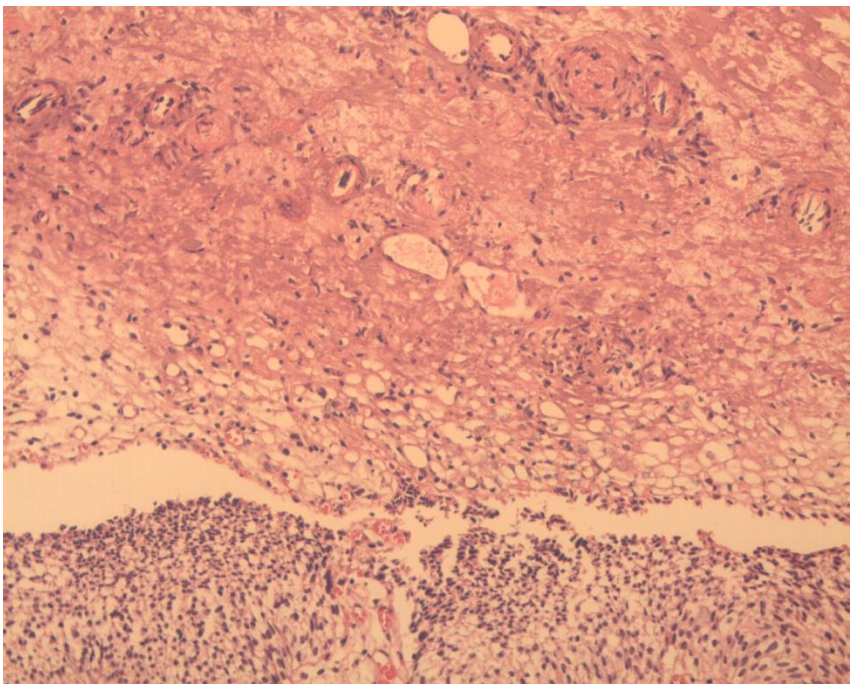
The resection time was not significantly different between both arms.

The quality of resection was determined by a single pathologist as described previously. Completeness resection of the tumour was possible in over 90% of cases in both groups. Deep muscle was identified in the sample in over 95% cases in both groups. Severe cautery artifact (previously defined as the majority of chips with >50% artifact) was significantly more common in the monopolar arm (p=0.0096).

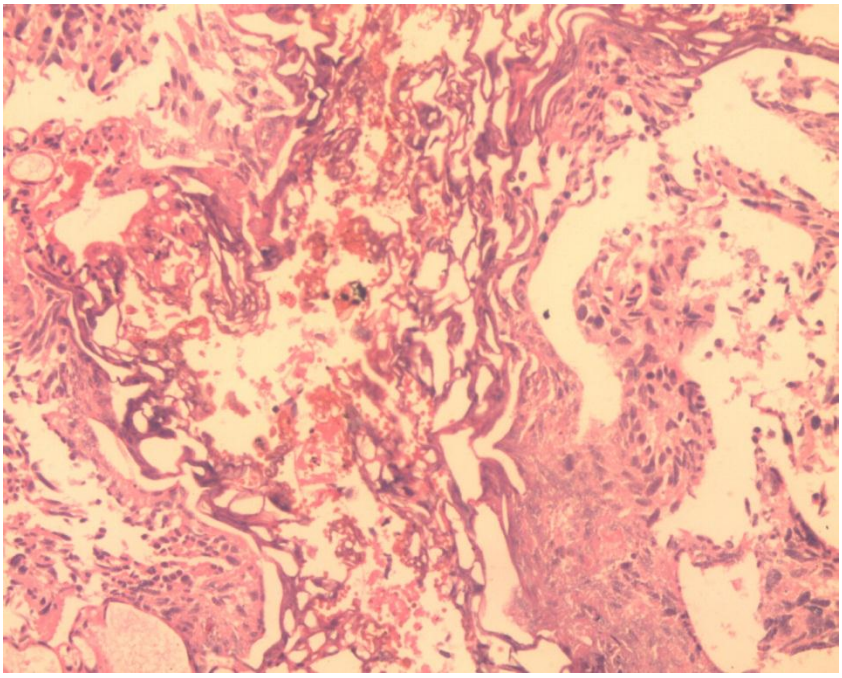
Table 5 – Intention to treat analysis			
Event	Monopolar n=75	Bipolar n=72	p
Obturator jerk (%)	29 (49.2)	33 (60)	0.27
Bladder perforation (%)	12 (16)	12 (16.7)	1
Mean drop in PCV (SD)	3.07 (3.17)	3.11 (3.83)	0.95
Transfusion rate (%)	1 (1.3)	4 (5.6)	0.20
Re-coagulation/ clot retention (%)	3 (4)	4 (5.6)	0.72
Mean drop in Sodium (SD)	1.97 (4.65)	1.17 (3.08)	0.25
TUR syndrome (%)	2 (2.7)	0 (0)	0.49
Resection time (SD)	49 (32.5)	41.6 (23.1)	0.11
Gross residual tumour (%)	8 (10.7)	3 (4.2)	0.21
Presence of muscle (%)	71 (94.7)	69 (95.8)	1
Severe cautery artefact (%)	35 (46.7)	18 (25)	0.0096

The results of the per-protocol analysis of the two arms yielded similar results. The significance of the cautery artifact was magnified on per-protocol analysis with a p value of 0.0042.

Table 6 – Per-protocol analysis			
Event	Monopolar n = 69	Bipolar n = 68	P
Obturator jerk (%)	28 (50.9)	30 (57.7)	0.56
Bladder perforation (%)	12 (17.4)	12 (17.6)	0.97
Mean drop in PCV (SD)	3.18 (3.16)	3.11 (3.83)	0.92
Transfusion rate (%)	1 (1.5)	4 (5.9)	0.17
Re-coagulation/ clot retention (%)	3 (4.4)	4 (5.9)	0.68
Mean drop in Sodium (SD)	1.95 (4.73)	1.15 (3.10)	0.26
TUR syndrome (%)	2 (2.9)	0 (0)	0.49
Resection time (SD)	48.8 (32.5)	41.9 (23.4)	0.16
Gross residual tumour (%)	7 (10.1)	3 (4.4)	0.19
Presence of muscle (%)	65 (94.2)	66 (97.1)	0.41
Severe cautery artefact (%)	33 (47.8)	16 (23.5)	0.0042



(a)



(b)

Fig16: (a) TURBT chip showing only mild cautery artifact with preservation of cellular architecture.
(b) TURBT chip showing severe cautery artifact and distortion of architecture.

Discussion

Monopolar cautery has remained the gold standard for the resection of bladder tumours since its inception, however, complications can occur. With the establishment of bipolar resection as an efficient and safe alternative in transurethral resection of the prostate (11), it was natural that attention would be turned to its use in the resection of bladder tumours. Theoretical advantages included the elimination of the TUR syndrome, possible reduction in obturator jerks and bladder perforation, and better hemostasis during resection. (30–32,35,53) Studies done so far have shown some advantage but no high quality evidence exists to conclusively establish the role of bipolar resection in TURBT. (7)

Our study is among the first randomized controlled trials comparing monopolar and bipolar TURBT. We used a setting of 100W and 80W for cutting and coagulation respectively, for the bipolar resection.

The objective of our study was to assess the safety and efficacy of bipolar resection and compare it with the known standard of monopolar resection. This was assessed using a number of end-points that have been described previously. As described in the results section, both arms were well matched with respect to patient, tumour and surgeon factors.

The most important end-point that was assessed was the incidence of ***obturator jerk***. The exact incidence of this event varies widely in the reported literature. Average values range from about 10-25% to even over 50% for monopolar resection. (22–28,35,36,39,54)Values for bipolar resection are 0-5%. (29–32,34,35) Tumour location, and the use of general anesthesia with muscle relaxation, (36) or oburator block, (21,24–27,37–39,54) which are known to reduce obturator reflex, are sometimes not detailed in studies. This makes it difficult to judge the true incidence.

We eliminated this potential confusion by performing all resections under spinal anesthesia. Only tumours located on the lateral wall were included in the analysis of obturator reflex. Our study actually showed a slightly higher (but not statistically significant) incidence of obturator jerk in the bipolar arm (58.5 vs 50.9%). Other investigators have also shown that bipolar resection does not eliminate the risk of obturator jerk and can even cause bladder perforation. (30–33) Possible mechanisms include the initial high voltage needed to generate the plasma vapour pocket, (31) and the 'mushrooming' of current around the bipolar electrode with resultant transmission for several millimeters that could directly stimulate the nerve in subjects with thin bladder walls. (32) Gupta et al were able to eliminate nerve stimulation using settings of 50W for cutting and 40W for coagulation, but in our experience, these settings are too low for satisfactory resection. (31) Geavlette et al recently published a study in which they randomized patients with bladder tumours larger than 3cm to two groups. (35) The study group underwent resection using narrow-band imaging (NBI) cystoscopy and bipolar cautery. The control group underwent resection using traditional white-light cystoscopy and monopolar cautery. Obturator jerk occurred in 3 cases in the bipolar group versus 18 in the monopolar group ($P<0.001$). Bladder perforation was also significantly less common in the bipolar group (1.1 vs 7.2%, $p=0.03$). However, the anesthesia used in their study has not been mentioned.

Bladder perforation is an often under-reported complication of TURBT. The classical incidence quoted is about 5%. (14) In our study, 12 patients in each group (about 16%) had bladder perforation. Only 1 needed laparotomy and closure of the perforation. The remainder were conservatively managed with prolonged catheter drainage. The larger than reported incidence of bladder perforation could be secondary to the large proportion of sessile and invasive tumours seen in our study.

Resection at our department aims at complete excision of all tumours, and in this type of tumour (sessile and invasive), bladder perforation is a possible consequence.

Another quoted advantage of bipolar resection is excellent hemostasis. (11,29–32,35) In our study there was no significant difference in the transfusion rate or change in hematocrit in both arms. Four patients in the bipolar arm developed clot retention and needed re-coagulation of bleeders, as opposed to 3 in monopolar arm. In the study by Xishuang et al, 1/51 patients in the monopolar group as opposed to 0/58 patients in the bipolar group needed a post-operative transfusion. No comparison between pre-operative and post-operative hemoglobin or hematocrit is available in their study. (29) Similarly, Geavlette et al have also shown a significantly lower drop in hemoglobin using the bipolar cautery, however there was no significant difference in transfusion or re-coagulation rates. (35)

Hyponatremia after TURBT occurs following absorption of extravasated fluid from the peritoneal cavity and is typically gradual (about 10 hours) in onset. (14,19) In this way it is distinct from the hyponatremia seen in TURP. Bipolar resection eliminates its occurrence by allowing resection to be performed with normal saline. In our study no patient who underwent bipolar TURBT developed TUR syndrome, as opposed to two patients in the monopolar arm. Both occurred during resection for large tumours (>5cm), with a resection time in excess of 1 hours. This finding has been observed in other studies on bipolar TURBT, as well as TURP. (11,29–32,35) The mean drop in serum sodium was also lower in the bipolar arm but it did not reach statistical significance. Our study was underpowered to detect any significant difference in this outcome; however, the general incidence of TUR syndrome following TURBT is so low that a sample size in the thousands would be required to prove statistical significance.

In the elderly, and patients with prior cardiac or renal dysfunction, the ability to resect without the fear of precipitating fluid and electrolyte imbalances may prove invaluable. As the patient is likely to remain stable throughout the procedure, a more thorough resection is likely using the bipolar system. Therefore in high-risk patients, the bipolar system may prove to be the resection method of choice. (31,47)

Complete resection is an important indicator of the quality of TURBT and was possible in over 90% of cases in both arms. Presence of muscle in the specimen was also identified in about 95% of cases. Trained consultants or residents under their supervision performed all resections. This is probably responsible for the completeness of resection rather than the contribution of any particular cautery system. Training and surgeon experience have been shown to be important factors in the quality of a TURBT. (5)

Concern over the quality of pathological specimen received from bipolar resection arose due to the fact that the bipolar loop is slightly smaller. (45) Two small studies in the past showed no difference in the quality of the pathological specimen received from bipolar TURBT. (45,46) A recent Korean study confirmed these findings. (51) ***Cautery artifact*** occurs as a result of contact of the heating loop with the tissue and can affect accurate interpretation of tissue samples. It is dependent on the heat generated during resection, duration of contact of the loop with the tissue, the size of the loop and composition of tissue. (45) Three other studies have examined the difference in the artifact obtained during monopolar and bipolar resection and concluded equivalence in the chips obtained using both systems. (45,46,51) In our study, the incidence of severe cautery artifact was significantly lower in the bipolar arm. The reduced charring of tissues and lower temperature used during bipolar resection could be contributory factors to the better preservation of tissue architecture

that was seen in these cases. (5,29) However our pathologist as able to come to an accurate diagnosis in all cases. When tissue specimen is scanty (example scar resections or incomplete resections), or the pathologist is inexperienced, these differences in cautery artifact may prove to be more clinically relevant.

While our study remains among the first randomized trials comparing monopolar and bipolar TURBT, limitations exist. Different surgeons performed the resection. However, both arms were well matched with respect to surgeon experience. In addition, studies have shown no difference in the learning curve for bipolar resection. (11,34) We believe that the fact that different surgeons performed the resection means that our results are more generalizable to the population of practicing urologists.

Protocol violations occurred in 10 cases. Eight of these were in lateral wall tumours where the anesthetist inadvertently gave general anesthesia. One case underwent simultaneous ureteroscopy, and another was a very small tumour where laryngeal mask airway was used. While these cases were excluded from per-protocol analysis, the intention-to-treat analysis performed included these cases, and showed no significant differences in both arms. While it would have been preferable to have no violations in our study, our statistical findings are consistent and attest to the strong design of the trial.

Follow up to assess the incidence of urethral stricture is not yet complete. The large proportion of recurrent tumours in our patients may make a meaningful comparison of this difficult. Loops were re-used for more than one case, however, the exact impact of this on the study findings in unclear.

Additionally, the study was underpowered to detect any significant difference in TUR syndrome among the 2 groups. However, a sample size in the thousands would be required in this case owing to the rarity of the event itself.

The principal investigator could not be blinded for unavoidable reasons, and this is a potential limitation of our study. However, the blinding of the pathologist and statistician are strengths that are worth reiterating.

We believe the external validity of this study is strong. Being a tertiary referral centre, we were able to include the complete spectrum of bladder tumours in our study. The low number of female patients (<6%) is a potential limitation but this appears representative of the situation in India. (31)

Conclusion

Our study demonstrates that bipolar resection appears to be equivalent to monopolar resection in the performance of TURBT.

The only benefit clearly demonstrated in our study is significant reduction in severe cautery artifact obtained with bipolar resection. This may allow better interpretation of the pathological sample.

There was no instance of TUR syndrome in the bipolar arm, and this may be beneficial in allowing complete resection in high-risk patients without the fear of precipitating fluid-electrolyte disturbances. However, our study was underpowered to detect the statistical significance of this outcome.

Other purported advantages like better hemostasis and a reduced incidence of obturator jerk and bladder perforation were not observed in our study.

Further well-conducted randomized studies are required to determine the exact role of bipolar TURBT in the urologists' armamentarium.

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Annexures

Hospital No	Age	Sex	Monopolar/Bipolar	Comorbidities	ASA	Smoker	Preop PCV
263996D	65	1	0	0	1	1	43
020393F	73	1	0	1	2	1	32.3
095594F	79	1	0	3	2	0	30.4
130254F	62	1	0	2	2	1	37.8
053210F	43	1	0	0	1	1	46.5
695684D	75	1	0	0	2	1	32.3
475821D	47	1	0	0	1	1	38.3
091937F	66	1	0	8	2	1	40
108403F	42	1	0	0	1	1	44
927086D	53	1	0	0	1	0	22.5
033637F	75	1	0	1	2	1	33.2
125995F	55	1	0	0	1	0	39.6
960471D	39	1	0	0	1	1	40.9
047207F	23	1	0	0	1	1	40.5
035792F	39	1	0	0	1	0	39
939322B	53	1	0	0	1	0	36.2
947047D	44	1	0	0	1	0	38.1
747464C	55	1	0	2	2	0	34.2
945392D	49	1	0	0	1	1	37.8
367816D	63	1	0	0	1	1	31.7
958334D	68	1	0	1	2	1	38.1
111943F	57	1	0	1	2	0	35.4
014294F	44	1	0	2	2	1	33.6
258558F	29	1	0	6	2	1	38
070795F	50	1	0	1	2	0	40
258451D	53	1	0	0	1	1	45.9
874839D	65	1	0	0	1	0	38.5
976545D	56	1	0	0	1	1	39.3
494353D	47	1	0	1	2	1	40.6
254913F	68	1	0	8	3	1	35.8
195447F	38	1	0	1	2	0	43.6
026297F	24	1	0	0	1	1	46.5
947919C	57	1	0	8	2	1	38.2
945031D	67	1	0	0	1	0	34.5
193541F	40	1	0	0	1	1	39.3
232536F	58	1	0	0	1	1	40.2
976464D	64	1	0	8	3	1	36.6
063073F	67	1	0	0	1	1	35.7
114972F	70	1	0	8	2	1	39.8
132070F	33	1	0	0	1	0	41.1
014223D	64	1	0	0	1	1	34
870620B	56	0	0	8	2	0	35.7
204706D	57	1	0	1	1	1	42.3
977045D	52	1	0	4	2	1	24.3
926213D	57	0	0	0	1	0	32.4
221547F	60	1	0	1	2	0	35.5
092897F	59	1	0	2	2	0	40.8
009992F	60	1	0	0	1	1	39.2
128250F	54	1	0	2	2	1	27.5
406370D	64	1	0	2	2	0	38.5
879164D	69	1	0	1	2	1	35.6
951682D	69	1	0	0	1	1	41.2
960652B	51	1	0	0	1	1	24
696680C	82	1	0	1	2	0	40.5
936512D	60	1	0	2	1	1	37.7

162044F	63	1	0	3	2	1	31.3
941971D	64	1	0	1	2	1	39
238146F	50	1	0	0	1	1	30
153156F	50	1	0	0	1	1	39.9
031987F	64	1	0	1	1	0	36.2
813707D	44	1	0	2	2	0	44.2
262548F	32	1	0	2	2	0	42.3
970892D	63	1	0	1	1	1	39.2
954272D	41	1	0	1	1	0	44.1
910551D	58	0	0	8	2	0	25.2
057750F	55	1	0	2	2	1	27.6
060287F	64	1	0	0	1	1	
313497D	43	0	0	6	2	0	33
601724C	44	1	0	1	2	1	46.8
769677C	50	0	0	0	1	0	35.8
076614F	72	1	0	1	2	1	28.4
649625D	55	1	0	0	1	1	35.1
014223D	65	1	0	0	1	0	36.4
977774D	52	1	0	0	2	0	25.8
138258F	61	1	0	0	1	0	39.3
258496F	60	0	1	8	3	0	26.8
104498F	80	1	1	0	1	0	34.1
088719F	49	1	1	8	2	0	37.2
037139F	61	1	1	1	2	1	36.1
172239F	59	1	1	8	2	1	36.6
157540F	32	1	1	0	1	0	39.6
236765F	72	1	1	2	2	1	33.3
757899C	54	1	1	0	1	1	39.9
533379D	59	1	1	2	2	1	39.6
893859D	68	1	1	8	2	0	38.6
125048F	34	0	1	0	1	0	39.2
933211D	39	1	1	0	1	1	43
025315F	69	1	1	1	2	1	42.6
262246F	35	0	1	0	1	0	36.3
943129C	70	1	1	0	1	1	37.5
926056D	56	1	1	0	1	1	41.9
921477D	57	1	1	2	2	1	37.5
173330F	26	1	1	0	1	0	44.4
904990D	50	1	1	0	1	1	41.4
367816D	64	1	1	0	1	1	34.2
956687D	41	1	1	0	1	1	21.7
116854F	64	1	1	0	2	1	37.4
899759D	58	1	1	8	2	1	31.6
137451F	62	1	1	0	1	0	41.7
967480D	49	1	1	0	1	1	40.9
031948F	39	1	1	0	1	1	38.8
113974F	54	1	1	0	1	1	25.8
195515F	53	1	1	0	1	1	38.4
957673D	49	1	1	1	2	1	40.5
193606F	73	1	1	2	2	1	38
817420C	67	1	1	2	2	1	42.6
357016D	50	1	1	0	1	1	40.2
157360F	61	1	1	0	1	1	38.4
186195F	56	1	1	0	1	1	30
154518F	76	1	1	1	2	1	38.4
118889F	47	1	1	0	1	0	29.4

990086D	45	1	1	0	1	1	36
196232F	42	1	1	0	1	0	36
682076D	58	1	1	6	2	0	41.4
939962D	51	1	1	0	1	1	41.1
098756F	72	1	1	1	2	1	37
203702F	51	1	1	2	2	1	44.5
011831F	38	1	1	0	1	0	39.3
329303D	60	1	1	2	2	1	36
057317F	64	1	1	8	2	0	34.8
146866F	60	1	1	2	2	1	26.9
225738F	70	1	1	3	2	1	40.1
045765F	65	1	1	1	2	0	42.7
004496F	60	1	1	8	2	0	32.5
012773F	64	1	1	0	1	1	36.4
040571F	45	1	1	0	1	1	42.3
083742F	70	1	1	0	1	1	33
146049F	45	1	1	0	1	1	27.3
248034F	43	1	1	0	1	1	40.5
974830D	61	1	1	0	1	1	37.1
026202F	62	1	1	8	2	1	37.5
123430F	65	1	1	0	2	0	31.8
118550F	68	1	1	0	2	1	39.7
009240F	47	1	1	2	2	0	43
960808D	70	1	1	0	1	0	42.3
813707D	44	1	1	2	2	0	43.9
216318F	40	1	1	0	1	1	42
258578F	36	1	1	0	1	1	32.7
188622F	56	1	1	0	1	0	41.2
969325D	42	1	1	0	1	1	48.6
116728F	48	1	1	1	2	1	37.3
059049F	57	1	1	2	2	0	42.6
726834D	58	1	1	3	2	1	40.4
837044D	32	0	1	0	1	0	33.9
154175F	59	1	1	0	1	1	35.2
156940F	48	1	1	1	2	1	38.4
941183D	87	1	1	0	2	0	28.8

PCV at 48hr	PCV difference	Preop Na	Na at 12hr	Na difference	Symptomatic hyponatrem
39.4	3.6	137	136	1	0
28.3	4	125	127	-2	0
31.1	-0.7	135	135	0	0
37.2	0.6	135	128	7	0
39.1	7.4	136	134	2	0
30.6	1.7	130	128	2	0
33.7	4.6	141	136	5	0
34	6	132	131	1	0
41.9	2.1	132	136	-4	0
23.6	-1.1	136	135	1	0
33.9	-0.7	126	127	-1	0
37.8	1.8	132	121	11	1
36.9	4	139	139	0	0
34	6.5		136		0
37.7	1.3	135	135	0	0
32.6	3.6	143	135	8	0
39.1	-1	139	139	0	0
33.2	1	136	137	-1	0
30.8	7	140	137	3	0
		131	132	-1	0
39.2	-1.1	136	137	-1	0
35.6	-0.2	132	130	2	0
26	7.6	140			0
28	10	134	131	3	0
39.1	0.9	140	138	2	0
42.9	3	134	140	-6	0
		137	134	3	0
		136	137	-1	0
44	-3.4	135	135	0	0
32.7	3.1	131	131	0	0
40.8	2.8	136	134	2	0
41.1	5.4	134			0
36.7	1.5	139	137	2	0
30.8	3.7	141	133	8	0
36.1	3.2	137	136	1	0
35.7	4.5	140	137	3	0
23.2	13.4	135	125	10	0
33.1	2.6	137	134	3	0
35.2	4.6	134	134	0	0
			139		0
29.1	4.9	137	108	29	1
32.2	3.5	136	134	2	0
34	8.3	139	142	-3	0
21.2	3.1	143	138	5	0
24.2	8.2	131	133	-2	0
35.6	-0.1	134	132	2	0
35	5.8	134	128	6	0
33.8	5.4	141	139	2	0
27.5	0	133	132	1	0
34.6	3.9	139	133	6	0
		137	135	2	0
40.2	1	134	132	2	0
25.9	-1.9	138	137	1	0
36.1	4.4	130	129	1	0
33.6	4.1	139	137	2	0

32.6	-1.3	139	135	4	0
33.4	5.6	138	137	1	0
25.6	4.4	132	135	-3	0
36.3	3.6	135	136	-1	0
32.3	3.9	127	133	-6	0
41.8	2.4		141		0
41.3	1	141	136	5	0
31.4	7.8	137	134	3	0
		138	139	-1	0
24.7	0.5	136	137	-1	0
26	1.6	137	134	3	0
36.5		136	135	1	0
34.2	-1.2	135	137	-2	0
41.8	5	133	130	3	0
		138			0
28.8	-0.4	132	131	1	0
		136			0
		138	133	5	0
26.1	-0.3	135	134	1	0
		139			0
28.6	-1.8	138	134	4	0
30.6	3.5	133	136	-3	0
34.1	3.1	137	138	-1	0
34.9	1.2	136	133	3	0
35.6	1	136	137	-1	0
41.6	-2	138	134	4	0
29.7	3.6	137	138	-1	0
33.9	6	135	130	5	0
36.4	3.2	140	137	3	0
37.4	1.2	136	131	5	0
40.3	-1.1	128	131	-3	0
44.2	-1.2	142	140	2	0
34	8.6	136	137	-1	0
30.2	6.1	139	136	3	0
37.1	0.4	139	134	5	0
39	2.9	143	138	5	0
34.9	2.6	142	141	1	0
45.8	-1.4	136	137	-1	0
37.4	4	140	140	0	0
		132			0
22.7	-1	140	137	3	0
33.4	4	137	136	1	0
33.6	-2	138	138	0	0
18.9	22.8	141	135	6	0
34.9	6	140	136	4	0
36	2.8	137	135	2	0
20.7	5.1	138	136	2	0
33.7	4.7	138	132	6	0
35	5.5	138	136	2	0
39.2	-1.2	138	133	5	0
40.1	2.5	132	132	0	0
		138	134	4	0
38.3	0.1	137	137	0	0
30.7	-0.7	137	135	2	0
34.7	3.7	141	133	8	0
25.7	3.7	133	134	-1	0

34	2	138	135	3	0
36.9	-0.9		135		0
36.2	5.2	131	137	-6	0
36	5.1	137	140	-3	0
36.1	0.9	128	130	-2	0
31	13.5	134	133	1	0
37.9	1.4	139	139	0	0
32.6	3.4	136	136	0	0
32.1	2.7	126	134	-8	0
20.8	6.1	134	137	-3	0
40.3	-0.2	129	132	-3	0
38.5	4.2	135	134	1	0
30.7	1.8	135	133	2	0
35.9	0.5	130	130	0	0
38.8	3.5	131	137	-6	0
27	6	137	138	-1	0
26.7	0.6	136	135	1	0
35.8	4.7	137	133	4	0
34	3.1	137	133	4	0
28.1	9.4	138	138	0	0
28.1	3.7	138	135	3	0
36.9	2.8	135	136	-1	0
38.5	4.5	140	135	5	0
37.1	5.2	138	133	5	0
44.1	-0.2	136	135	1	0
		139			0
31.3	1.4	141	139	2	0
37.1	4.1	137	136	1	0
		139	138	1	0
36	1.3		138		0
38.3	4.3	137	136	1	0
37.2	3.2	137	138	-1	0
		138			0
		137			0
		138			0
		142	140	2	0

Tumour number	Size (combined)	Length	Breadth
2	5*4	5	4
1	2*1	2	1
1	4*2	4	2
1	1*1	1	1
2	5*5	5	5
1	0.5*0.5	0.5	0.5
2	1*1	1	1
7	3.5*3.5	3.5	3.5
8	8*4	8	4
1	9*7	9	7
1	2*2	2	2
3	14*10	14	10
1	2.5*2.5	2.5	2.5
1	2*1	2	1
5	4*3	4	3
2	1.5*1.5	1.5	1.5
3	6*5	6	5
3	2*2	2	2
4	2.5*2.5	2.5	2.5
8	8*8	8	8
1	3*2	3	2
2	2.5*2.5	2.5	2.5
3	12*9	12	9
3	6*8	6	8
1	3*3	3	3
2	4*3	4	3
1	4*3	4	3
1	4*3	4	3
1	3*3	3	3
1	3*4cm	3	4
1	2*2	2	2
1	4*2	4	2
1	2*2	2	2
2	5*4	5	4
1	1*1	1	1
1	7*7	7	7
1	10*8	10	8
3	6*6	6	6
2	4*4	4	4
5	10*10	10	10
4	8*6	8	6
1	4*2	4	2
1	3*3	3	3
1	5*5	5	5
1	10*7	10	7
1	2.5*2.5	2.5	2.5
1	4*3	4	3
1	4*3	4	3
1	6*8	6	8
3	4*4	4	4
1	1.5*1.5	1.5	1.5
1	3*2	3	2
3	7*6	7	6
1	3*2	3	2
1	4*4	4	4

1	6*6	6	6
2	4.5*4.5	4.5	4.5
1	9*6	9	6
7	22*20	22	20
1	6*4	6	4
2	2*2	2	2
1	4*5	4	5
1	2*2	2	2
1	1*1	1	1
1	1*1	1	1
1	1*1	1	1
1	2*0.5	2	0.5
1	1*1	1	1
5	10*10	10	10
2	3*2	3	2
1	3*1.5	3	1.5
1	3*3	3	3
3	0.8*0.8	0.8	0.8
1	7*5	7	5
1	5*4	5	4
1	4*3	4	3
1	4*3	4	3
1	3*3	3	3
1	2*1	2	1
2	4*3	4	3
1	4*3	4	3
1	1*1	1	1
2	2*2	2	2
6	3*3	3	3
1	1*1	1	1
1	2.5*1.5	2.5	1.5
1	2*2	2	2
1	3*2	3	2
2	4*4	4	4
3	6*3	6	3
2	4*2	4	2
4	7*7	7	7
1	3*3	3	3
1	2*2	2	2
10	5*5	5	5
14	16.5*16	16.5	16
4	4*2	4	2
2	1.5*1.5	1.5	1.5
1	3*3	3	3
1	4*4	4	4
1	4*4	4	4
1	5*3	5	3
1	4*4	4	4
1	2*2	2	2
1	3*2	3	2
1	2*2	2	2
3	6*6	6	6
5	3*3	3	3
1	2*1	2	1
1	1*1	1	1
1	3*2	3	2

20	28*26	28	26
1	6*6	6	6
1	3*3	3	3
1	3*2	3	2
5	3.5*2.5	3.5	2.5
6	6*6	6	6
7	8*8	8	8
8	9*9	9	9
1	3*3	3	3
1	6*5	6	5
3	5.5*5.5	5.5	5.5
1	6*5	6	5
1	5*4	5	4
1	3*3	3	3
1	4*3	4	3
1	4*4	4	4
1	6*5	6	5
1	3*2.5	3	2.5
3	2.5*2.5	2.5	2.5
1	6*5	6	5
1	8*7	8	7
5	15.5*14.5	15.5	14.5
7	9*9	9	9
2	3*3	3	3
1	3*3	3	3
1	2.5*1	2.5	1
1	3*3	3	3
1	4*5	4	5
1	2*2	2	2
6	6*6	6	6
1	1*1	1	1
3	3*2	3	2
1	0.5*0.5	0.5	0.5
1	1*1	1	1
1	2*1	2	1
1	1*1	1	1

Papillary/ Sessile	Primary/ Recurrent	Location	Surgeon	Conversion to GA	Resection time
1	0	1	1	1	35
0	1	1	0	0	55
1	1	1	0	0	35
1	1	2	2	0	10
1	1	2	1	0	45
1	0	4	0	0	15
1	0	6	1	0	20
1	1	6	0	0	30
1	1	6	1	0	20
0	1	1	1	0	60
1	1	1	1	0	20
0	1	6	0	0	80
1	1	1	1	0	25
1	1	1	0	0	45
1	1	1	1	0	30
1	0	6	0	0	20
1	0	6	1	0	60
1	0	6	0	0	60
1	1	7	1	0	20
1	0	1	1	0	150
1	1	1	0	0	20
1	1	2	0	0	30
1	1	6	1	0	120
1	1	6	2	0	150
0	0	1	0	0	40
1	0	1	1	0	50
0	1	1	2	0	60
0	1	1	1	0	35
0	1	1	1	0	30
0	1	1	1	0	45
1	1	1	1	0	40
1	1	1	1	0	30
1	1	1	2	0	20
1	1	1	0	0	30
0	0	3	2	0	30
0	0	6	1	0	30
0	0	6	1	0	120
1	0	6	1	0	45
1	1	6	1	0	30
1	1	6	1	0	45
0	0	7	0	0	45
0	0	1	1	0	90
0	0	1	2	0	35
0	0	1	2	0	60
0	1	1	1	0	140
0	1	1	0	0	25
0	1	1	1	0	30
0	1	1	1	0	25
0	1	1	0	0	120
1	1	1	1	0	80
1	0	2	1	0	30
0	0	6	1	0	20
0	0	6	0	0	65
0	1	6	1	0	60
0	1	6	1	0	45

0	1	6	1	0	60
0	1	6	1	0	80
1	1	6	2	0	70
1	1	6	2	0	90
0	1	7	1	0	70
1	0	1	1	0	30
0	1	1	1	0	45
0	1	1	0	0	60
1	1	1	1	0	20
0	0	2	2	0	20
1	0	2	1	0	20
1	1	2	1	0	30
1	0	4	0	0	30
1	1	7	1	0	35
1	1	1	0	0	30
0	1	1	1	0	45
0	1	3	1	0	45
1	0	1	0	0	30
1	1	4	2	0	120
1	1	1	1	0	40
0	1	1	1	0	25
1	1	1	1	0	45
1	1	1	1	1	30
1	1	1	1	0	30
1	1	1	0	0	20
1	0	4	0	0	25
1	1	4	1	0	30
1	0	6	0	0	25
1	0	6	1	0	40
1	0	1	2	0	25
1	1	1	0	0	30
1	1	1	1	0	30
1	1	1	0	0	30
1	1	1	0	1	50
1	0	6	1	0	45
1	1	6	1	0	15
1	1	6	2	0	50
1	1	1	0	0	30
1	1	1	2	0	30
1	0	6	0	0	45
1	0	6	1	1	60
1	0	7	0	0	30
1	0	1	1	0	30
1	1	1	1	1	45
1	1	1	0	0	30
1	1	1	1	0	60
1	1	1	1	1	40
1	1	1	0	0	60
1	1	1	2	0	30
1	1	1	2	0	15
1	1	1	0	0	55
1	1	1	1	1	60
1	1	1	1	0	25
1	0	2	0	0	30
0	0	3	0	0	30
1	1	3	2	0	45

1	0	6	2	0	60
0	1	6	2	0	60
1	1	6	1	0	25
1	1	6	2	0	30
1	1	6	2	0	45
1	1	6	1	0	65
1	0	7	0	0	30
1	0	7	1	0	120
0	0	1	1	0	80
0	0	1	1	0	60
1	0	1	0	0	45
0	1	1	1	0	90
0	1	1	2	0	40
0	1	1	1	0	35
0	1	1	1	0	30
0	1	1	1	0	60
0	1	1	1	0	60
0	1	1	2	0	20
1	1	1	0	0	45
0	1	3	1	0	30
0	1	6	2	0	160
1	1	6	1	0	60
1	1	6	1	0	25
0	1	7	1	0	30
0	0	3	2	0	30
0	1	1	1	0	30
0	0	2	1	0	30
1	1	2	2	0	45
1	1	2	1	0	30
1	1	2	0	0	20
0	1	4	0	0	20
0	1	6	1	0	45
1	0	2	2	0	20
0	1	1	2	0	30
1	1	1	0	0	60
1	1	1	2	0	30

Obturator jerk	Perforation	Gross residual tumour	Transfusion	Clot retention/ re-coagulation
1	0	0	0	0
1	1	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	1	0	0
1	0	0	0	0
1	1	0	0	0
1	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	1
0	0	1	1	1
1	0	0	0	0
1	1	0	0	0
0	0	0	0	0
0	0	1	0	0
1	1	0	0	0
1	1	0	0	0
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Muscle present	T stage	Grade	Cautery artef	Adverse event
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